



Quantitative Risk Assessment

**Former Monckton Coking Works,
Lund Hill Lane,
Royston,
Barnsley,
South Yorkshire,
S71 4BD**

For

Monckton Developments Limited

July 2020

20.B0010.5.1

Geo² Remediation Limited

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Revision Log

Version	Date	Issue	Approved By
1	27/07/20	First Issue	Adam Wilson

Monckton Developments Limited

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1.0 Introduction

Geo² Remediation Limited have been commissioned by Monckton Developments Limited to conduct a Quantitative Risk Assessment of the Former Monckton Coking Works, Lund Hill Lane, Royston, Barnsley, S71 4BD (the site).

The site comprising a former coal stockyard, colliery and coking plant which, at the time of writing, had ceased trading and has largely been demolished to slab level, in preparation for a proposed redevelopment programme.

This report follows and is developed upon the findings of a programme of site investigation, reported separately, but summarised were relevant herein for convenience.

This report aims to determine the extent and significance of land contamination encountered beneath the site to ensure that potential risks to future site users and the environment may be addressed as part of the redevelopment.

This report does not aim to assess issues associated with geotechnical, structural or coal mining hazards to the site.

2.0 Site Setting

2.1 Site Location

The site is located on Lund Hill Lane, Royston, to the northeast of Barnsley, South Yorkshire; at a National Grid reference of 437460, 412020, as shown on Figures 1 and 2 in Appendix A.

At the time of writing, most of the site has been reduced to slab, or sub slab level, with a few structures remaining associated with the historical workings of the site, either in a state of dereliction or retained for maintenance and operation of utility supplies.

The former engineering workshop remains on the eastern boundary, and a portion of the land beyond the eastern boundary has been redeveloped into offices and car parking for Hargreaves Industrial Services plc.

The site is accessed from two main entrances along the eastern boundary, from Lund Hill Lane; the northernmost entrance allowing access through a weighbridge to the former stockyard and Engineering Workshops, the southern entrance allowing access to the Hargreaves property (which will be considered as offsite in this assessment) and an effluent treatment plant in the far south of the site.

2.2 Site Areas

For convenience many of the historic reports have separated the site into three key areas, divided by the current and historical activities which have taken place. These area designations and names will be adopted herein. The extents of each of these areas is shown on Figure 3, in Appendix A.

- **Stockyard and Colliery Area**

The northernmost portion of the site; formerly occupied by the coke and coal stockyards. This area was the hub of the former colliery operations including numerous buildings and rail tracks.

This area is currently level and largely demolished to slab level, with the exceptions of the Engineers Workshop building and occasional small structures. The former structures in this area were used as workshops, mobile plant refuelling, effluent handling and storage.

This area appears surfaced with a thin layer of black coke dust 'breeze'.

In the northwest corner of the site remain a series of Quench Ponds which appear to remain intact and holding water.

Three mine shafts are understood to be present in this area, records indicate these have been capped.

A portion of the north east of the stockyard area, is surrounded by an earthen bund and is wooded.

The engineering workshop was situated adjacent to a waste storage and collection area. A substation was also indicated to be in this area.

Currently large stockpiles of high silica content brickwork associated with the demolition of structures onsite remain present on the site.

- **Former Production and By-Products Area**

This forms the centre of the site including the Combined Heat and Power (CHP) infrastructure, coking ovens and conveyors. This area includes plant associated with production of tar, benzole and ammonia. With the exception of the main tower of the coking ovens, all infrastructure here has been demolished to slab level.

This area comprises tightly packed concrete obstructions and building footprints, with much evidence of contaminative activities. Investigation encountered elevated concentrations of contaminants widespread around concrete infrastructure in shallow soils and penetrating the underlying bedrock.

- **Southern Site Section**

This area contains the effluent treatment plant, which has yet to be demolished and is predominantly wooded with coarse vegetation and semi-mature trees. Much of this area slopes steeply to the south.

- **Western Land Parcel**

This area lies to the west of the railway lines. This parcel of land is understood to be out with the boundaries of this site. It is understood that this area was formerly linked with a bridge to the main site and historically has been used for deposition of colliery spoil and more recently gas purification, storage and distribution.

This area of the site has been reported separately.

2.3 Site Levels

The ground levels are generally highest in the Process Area / Southern Area (near the footprint of the Combined Heat and Power (CHP) plant) at a height of approx. 72m AOD, the remainder of the site gently falls towards the north, with most of the Stockyard area at approximately 63m AOD. The southern area, slopes steeply from the rear of the CHP plant to a plateau, where the former Biological Treatment Plant remains at a level of 62m AOD.

The western and southern boundaries slope steeply downwards into the railway cutting and road bridge level (Road level spot height at south of site is 50.2m AOD). In the north, northeast and northwest the land level has been cut into the hillside where rudimentary retaining walls of tyres have been constructed.

A bund is present in the northeast, and around the site boundary in this area.

2.4 Site Setting

The site is situated in an area characterised by former coal mining activities, at the time of writing little of this infrastructure remains active. Current nearby landuses are summarised on Table 1, below.

North	Agricultural land and commercial facility, approximately 120m to the north. Beyond which lie disused industrial and agricultural land.
East	Lund Hill Lane (B6428), beyond which lies grassed disused industrial land and a timber recovery facility.
South	Lund Hill Lane (B6428), beyond which lies former industrial land now Rabbit Ings Country Park.
West	Railway Cutting, beyond which lies agricultural land and residential properties approx. 120m beyond the site boundary. The Barnsley Canal lies approximately 200m to the west.

Table 1: Surrounding Land Uses

2.5 Sensitive Receptors

Reports have not identified any land use designations, such as SSSIs or similar. Areas of green belt are present in the surrounding land and the site falls within a Nitrate Vulnerable Zone.

2.6 Proposed Development

The Client is looking to redevelop the site as a residential development including circa 400 homes, areas of public open space and roadways.

Due to the current topography of the site, it is understood that the Stockyard and Southern areas are likely to include significant land level rises, to match the surrounding landscape and access routes more closely. Whilst final site levels have yet to be established it is understood that the Stockyard will be elevated from circa 63m AOD to approx. 67-70m AOD. The Production and Southern Area are likely to remain similar to their current levels of 72m and 62m AOD respectively.

The proposed change in land levels has a significant impact upon the risk assessment undertaken herein.

The development aims to locate historical mine shafts in public open space areas and utilise the topographically lower southern area to incorporate public open space and utility areas. The Southern area will predominantly be used as a green corridor linking to the neighbouring Rabbit Ings Country Park and providing leisure space.

A current site layout plan is incorporated in Figure 2 and a proposed development plan is shown on Figure 3, in Appendix A.

3.0 Summary of Previous Works

3.1 Previous Reports

This QRA should be read in conjunction with the following reports:

3.1.1 Data Review and Gap Analysis, 19/B010.1.2. Geo², 2019

Numerous historic reports have been made available for review providing limited detail with respect to the history, operation and ground condition of the site. The findings of these reports issued between the years of 1994 and 2017 have been incorporated into the Data Review and Gap Analysis report.

This report identified the key contaminants likely and proven to be present in the subsurface, including coal tar, DNAPLs, asbestos, hydrocarbons, cyanides, phenols, heavy metals, high calorific soils, silica bricks as well as numerous geotechnical and structural issues including three capped mine shafts.

This established a Conceptual Site Model and identified the gaps in this interpretation. Establishing an investigation design for subsequent work.

3.1.2 Site Investigation, 20/B010.4.1, Geo². 2020

Works comprised the creating of ninety-eight trial pits (TP1-98), ten window sampled wells (WS20-1 to WS20-10) and eight deeper boreholes (BH19-1 to 4, to 12m and BH19-5 to 8, to 20m).

Investigation covered all areas of the site and encountered volumes of calorific material and cyanides in the stockyard, proved the caps of the mineshafts, absence of infilled deposits and presence of former railway lines.

Contamination included DNAPL, cyanides, organic contaminants and tars as well as substantial volumes of concrete across the production and process area. The south of the site, although relatively free of gasworks infrastructure demonstrates elevated concentrations of cyanide in the groundwater.

The site investigation included a screening of identified contamination against generic assessment criteria and qualitative assessment of plausible pollutant linkages. It should be noted that generic assessment criteria have been used based on a residential end user, and these values have been applied as a basic screening method which does not take into consideration the impact of land level changes on exposure pathways.

3.2 Preliminary Conceptual Model

UK legislation and guidance on assessing potentially contaminated land recommends the use of a risk assessment process based on a review of source/pathway/receptor relationships for various environmental media.

A key component of the overall risk assessment process is identification of “relevant pollutant linkages” between contaminants and receptors. This can be accomplished through development of a site-specific conceptual model in which the potential contaminants, pathways and receptors identified on-site are described.

Works to date have allowed the production of a conceptual site model, which has been subsequently refined by site investigation.

Each element can be defined as follows:

- **Contaminant source:** A substance either on or under the land and which has the potential to cause harm or pollution to human or environmental receptors.
- **Pathway:** A route or means by which a receptor can be exposed to or affected by a source.
- **Receptor:** A living organism or an ecological system or, controlled water, or property including buildings, crops and livestock.

The presence of all three of the above elements identifies a pollutant linkage and a potentially unacceptable risk. Where a relevant pollutant linkage is established, this QRA will look to test, or to model the linkage, in order to refine and characterise the conceptual model and ultimately to assess the significance and severity of the risk.

Potential Source	Area	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Combustible Shallow Soils	Coal Stockyard	Direct contact, exposure, plus instability risk in event of fire	Future residential site users.	Low Likelihood	Severe	Moderate risk
PAH, Cyanide, Metal and Asbestos Contamination within Made Ground	Production Area and Coal Stockyard	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate /Low Risk
Hydrocarbon, Phenol and Tar / Oil Contamination	Production Area	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Severe	High Risk
		Groundwater Migration	Controlled Waters	Likely	Severe	High Risk
			Offsite Landusers	Low Likelihood	Mild	Low Risk
Ground Gases		Accumulation of Vapours or Gases	Future residential site users	Likely	Medium	Low Risk
			Offsite Landusers	Low Likelihood	Mild	Low Risk

Table 2: Preliminary Conceptual Site Model

Table 2, above, summarises the conceptual model derived in the Geo², Site Investigation Report (20/B0010.4.1). This report will look to further characterise those relevant pollutant linkages. Linkages considered to be of low risk, and shaded in the above table, are considered of insufficient severity of likelihood to require mitigation.

4.0 Linkage Review

Quantitative Risk Assessment ascribes values obtained from site testing and literature values to relevant characteristics which enable the development of a basic numerical model of each relevant pollutant linkage.

This section aims to review each stage of the relevant pollutant linkages to aid model selection.

4.1 Source

Each of the sources identified in Table 2, is discussed below.

4.1.1 Calorific Soils

The site investigation encountered soils of high calorific value widespread across the Stockyard area of the site as a mantle of 'breeze': a black, coke dust rich substrate. This appears to be present in a horizon up to 0.4m in thickness, a significant reduction in volume over that observed in historic reporting where up to 1.1m in thickness was encountered at the site. The mantle breeze extends slightly into the northwest of the production area and onto the former coal wharf.

Testing of this material has found that much of this has a calorific value in excess of 10mJ/kg and as such is flammable, with all other samples (all selected due to visual evidence of coal or ash within the sample matrix) from the production and stockyard areas reporting values in excess of the lower limit of 2mJ/kg (as proposed in the ICRCL 61-84, report, 1986).

As such Geo² consider all black, breeze material to be of sufficient calorific value to either be considered flammable or to be capable of sustaining a fire. This material may pose a risk through geotechnical or structural damage or risk to human health in the event of a fire. The distribution of this material has been well defined by the investigation programme.

These materials are not considered to be present across most of the production and process areas, or the southern areas of the site.

4.1.2 Cyanide, Metal and Asbestos Contamination within Made Ground

Made ground which was proven to a maximum depth of 4.0m bgl comprising predominately sandy gravels or gravelly sand with the occasional horizon of clay. Frequent cobbles of concrete and brick were present throughout with occasional brick walls or manholes identified. This is present across the Stockyard and Production Area, with a greater volume of concrete and rubble located around the Production Area

Contamination within the matrix has arisen through two routes.

- Through its mixed composition, which has included asbestos, or metals within waste incorporated into the deposit, or,
- Through subsequent contamination of these deposits by onsite processes.

Asbestos was anticipated in the Stockyard area within the breeze deposit, however thirteen samples from this and the underlying made ground only encountered trace evidence (max concentration of 0.127%) in two locations. Asbestos has also been encountered in three of five samples in the production area within the made ground, Geo² therefore consider that all made ground within the production area should be considered

as likely to contain trace evidence of asbestos (max concentration 0.017%, amosite and chrysotile board).

Metals contamination is present through the breeze and made ground, and there appears to be little evidence of clear hotspots, with screening targets sporadically exceeded for Lead, Mercury, Chromium and Selenium.

Data and visual evidence suggested shallow soil impacts associated with a clear point source for cyanides in both the Stockyard and Production areas, with corresponding evidence of cyanide impact also exceeding controlled waters screening values in the groundwater in some other areas.

Cyanides have been observed in excess of generic assessment criteria in groundwater samples obtained from the Southern Area; these samples are taken from shallow window samples installed within the natural clays. Logs from these areas indicate groundwater to be present within cohesive silt / clay deposits overlying weathered mudstone (encountered as a silt during drilling).

4.1.3 Hydrocarbon, Phenol, PAH and Tar / Oil Contamination

This impact is almost entirely associated with the Production Area (with the exception being TP80, along the western boundary), the Site Investigation encountered widespread evidence of tarry waste associated with former infrastructure, pipes, gullies and foundation blocks, throughout shallow made ground across the production area. This tarry material appeared predominantly to be of low mobility and was present as a viscous black coating, which became tacky in warmer weather. This material is likely to be of low volatility and mobility (TP28-TP32). Throughout this material pockets and pools of more mobile tars were encountered, whilst these appeared bound up in the structure, in the event of demolition or redevelopment this material may become mobilised. Areas displaying tarry and gasworks contamination within soils and associated with infrastructure are shown on Figure 4 and Figure 5, in Appendix A.

Key areas were found to contain evidence of greater volumes of tars and gasworks type contamination, including the following:

- The former Benzole Plant (BH19-07, BH19-06, TP45), where very high VOC readings were observed, and elevated PAH and phenol concentrations reported in soil and groundwater.
- A former ASTs area, (BH19-03, BH19-05) close to the former gasholder base, where elevated concentrations of hydrocarbons were reported in soils and groundwater, close to locations where DNAPL had historically been encountered. This area also exhibits elevated concentrations of cyanides and phenol in soils and groundwater.
- Tar sumps, full of a less viscous DNAPL product were encountered in the former Quench Tanks area to the west of the Coke Ovens, with substantial hydrocarbon contamination noted in shallow soils (TP23-TP26).

4.1.4 DNAPL in Groundwater

Whilst clear evidence of DNAPL has been identified within soils, in sumps around infrastructure and on the surface, no clear detectable DNAPL has been reported in boreholes as a measurable layer on an interface probe.

Samples obtained of DNAPL from sumps onsite or from the BH19-07 sample do not sufficiently quantify the volume or allow composition of the NAPL to the mass fraction of



individual components of the tar to be established. Therefore, the effective solubility of compounds with the mixture cannot be established (using Raoult's Law). Effective solubility is key in using the industry rule of thumb, which stated that where contaminants are present in a dissolved phase at greater than 1% of the compounds effective solubility, then this is indicative of DNAPL upgradient of the sample point (Environment Agency, DNAPL Handbook, R&D 133, 2003).

In the absence of this analysis, Geo² have utilised the 1% rule using the compounds pure phase solubility, which will produce a screening value substantially higher than the likely effective solubility and therefore represent a less sensitive indicator.

Screening using this method against the reported concentrations of US-EPA PAH 16 compounds indicates that sample data from BH19-02 and BH19-05, are clearly indicative of DNAPL in these areas. BH19-03 reports two values in excess of this screening value, however as these values are on the laboratory limit of detection, these are not considered a sufficient indicator of DNAPL.

On this basis, Geo² consider that DNAPL is likely to be present within the sandstone in the area of the Benzole Plant and around storage tanks in the west of the site.

4.1.5 Ground Gases

A limited ground gas assessment, comprising monitoring of installed boreholes for harmful gases (CO₂, CH₄, H₂S, CO and VOCs) was undertaken as part of the site investigation. This comprised 6 visits over a three-month period. This alone is insufficient to provide a suitable assessment in support of planning (which would require a 6 month assessment not a three month one), however, as the redevelopment proposes a substantial alteration of the ground level and is likely to incorporate a degree of remedial works, it is considered that the ground gas regime will be substantially altered by these works, and they are likely to significantly reduce any perceived risk to future residential homes. This hazard will not be assessed herein, and future characterisation will be addressed in the Remediation Strategy document.

Gases may also arise from volatile contaminants within soils, most clearly exhibited on this site in the benzole area by soils from depths of 0.5m (BH19-07, TP45). Volatilization of these contaminants may occur and act as a potential risk.

4.2 Receptors

Each of the receptors identified in Table 2, is discussed below.

4.2.1 Future Residential Site Users

As shown on the masterplan presented on Figure 3, in Appendix A, it is proposed to regenerate the site as a residential development comprising approximately 400 homes. These homes take the form of detached and predominantly semidetached properties with gardens and areas of public open space.

The proposed changes to land level will act to distance this receptor away from residual contamination, however, this assessment will still look to establish maximum safe concentrations of contamination to aid development of a remedial strategy and to assist in determining the suitability for use of materials retained onsite as part of the redevelopment.

4.2.2 Controlled Waters

Sampling of the groundwater beneath the site has demonstrated areas of contamination within the Production and Southern areas. Groundwater receptors are the following:

- The underlying Secondary A Aquifer, present within the underlying sandstone of the Mexborough Rock. The site is located outside of any source protection zones or abstraction points. The site investigation indicated that a single groundwater body is present beneath the site within the sandstone.

Levelling of the groundwater body has identified a north-eastern trend to the groundwater flow across most of the production and the stockyard area, as shown on Figure 6, in Appendix A. It should be noted that evidence of fracturing notes in rock outcrops suggested a potential for dual porosity, which may allow migration in other directions, however the findings of hydraulic conductivity testing did not provide evidence in support of this observation.

- The nearest surface water course is a culverted stream known as Lineside Dyke, situated approximately 50m west of the closest potentially significant impact. Located adjacent to the northern part of the western boundary of the main coking works site, Lineside Dyke flows in a generally southerly direction joining Cudworth Dyke approximately 140m to the south of the site

Lineside Dyke was noted to flow through an enclosed pipe buried at a shallow depth in the railway cutting adjacent to the base of the sandstone outcrop. Lineside Dyke was observed through a series of access manholes or vents along its length. Flow was noted to be low to nil on all visits.

Analysis from Lineside Dyke, collected at locations shown on Figure 7, in Appendix A, indicates concentrations of contaminants to be present far in excess of surface waters Environmental Quality Standards (EQS) for hydrocarbons, phenols, cyanides, metals and PAH. These concentrations have been reported both upstream (near the Stockyard - highest reading 9,180µg/l) and downstream (at the southwestern tip of the site) on all five sampling visits. The highest reported concentrations were consistently reported in the 'South' sample point (30,400µg/l TPH). This data strongly indicates that the Lineside Dyke is regionally impacted, however, there is clear evidence that the site is contributing to this impact. The most significantly elevated readings are all located at points immediately downstream of inlet connections with pipework which runs up the bank to the site.

Two other sample points Nos 3 and 4, sampled on one occasion (and shown on Figure 7), reported readings of 2,460µg/l and 3,132µg/l, respectively. These locations fall between the northern and southern sample points and are located away from identified pipe connections to the main site.

- One historic borehole, BH305, located in the east of the site is installed into a deeper sandstone horizon beneath the mudstone. Analysis from this waterbody does indicate elevated concentrations of contamination, in excess of screening values. As detailed in the Site Investigation it is considered that this well is likely to be in connectivity with the shallower water body in the sandstone encountered elsewhere on the site due to the coincidence in water levels.

4.3 Pathways

Each of the pathways identified in Table 2, is discussed below.

4.3.1 Direct Contact, Ingestion and Inhalation.

Future residential site users may become exposed to contamination through direct contact, inhalation and ingestion of contaminated materials. It is understood that the proposed development level will raise the Stockyard substantially, essentially providing a barrier severing this pathway. However, in the Production Areas the land levels are likely to remain similar and as such contaminated materials currently present within made ground in these areas may pose a risk should this material remain at a shallow depth or in garden areas.

4.3.2 Groundwater Migration

Groundwater levelling indicates that the topographic high point of the site, in the south of the production area, acts to divide the site into two watersheds, most of the site being covered by a watershed with a north easterly flow direction, with the remainder, comprising the grossly impacted areas of the production area, flowing to the southwest, towards the Lineside Dyke.

Lineside Dyke is located topographically lower than the site, being situated in a railway cutting along the western boundary at a level of approximately 53m-56m AOD, and as such groundwater along the western site boundary at a level of 61m- 64m AOD is likely to flow through the sandstone aquifer and enter into the proximity of the Dyke.

The method by which migrating groundwater through the Sandstone enters the Dyke is unclear, however it is likely that migrating groundwater will enter a baseflow of water around the culvert, where it may enter at joints or cracks.

Evidence suggests that release of water to the Lineside Dyke still occurs through residual infrastructure, which may account for the highest reported values within this waterbody. Pipework is visible in the bank connecting the watercourse to the site near the Stockyard, suggesting derelict pumping or drainage connections (as inferred in historical reports) and also by the Biological Treatment Plant in the south of the site.

Geo² consider the principal pathway by which Lineside Dyke has or is becoming impacted is the relict or disused drainage pipework. Migration through the deeper sandstone is considered likely to be contribute to this as well as regional diffuse / point sources associated with the coal mining legacy of the wider area.

Groundwater migration to the north across much of the site appears to be governed by the underlying mudstone, which slopes in the same direction.

Groundwater in the wells in the south of the site appears to be perched within shallow cohesive deposits, overlying the low permeability mudstone, as shown in Figure 8, in Appendix A. The mudstone appears to act as an aquitard across the site with groundwater trends in the north appearing to be governed by the slope of this low permeability horizon, as detailed in the site investigation. Groundwater levels in the Southern Area report a difference of 1m to water level within the wells, due to their close proximity and level topography of the southern area this provides further evidence of perched groundwater. As such, Geo² do not consider the groundwater in the Southern area to be significant waterbody or to have significant connectivity or contribution with the underlying aquifer or Lineside Dyke.

4.3.3 Accumulation of Vapours or Gases

High VOC soils, in excess of generic screening values have been encountered in locations across the production area, in particular in the former Benzole plant area. Permeable shallow soils, and potential permeable up fill materials may allow a pathway for vapour transmission to the surface. Vapours may accumulate beneath proposed residential buildings, gaining access through the floor slab or utility connections.

Volatile components within groundwater are considered to be present at greater than 2m in depth.

5.0 Model Selection

The primary objective of this QRA is to assess risk associated with the relevant pollutant linkages, identified as posing a medium or higher risk in the Qualitative Assessment, using the detail supplied above to populate a risk assessment model.

The QRA has been undertaken in accordance with the statutory guidance and procedures issued under Part 2A of the Environmental Protection Act 1990. In accordance with the UK tiered approach to risk assessment, chemical determinands in soils recorded in excess of generic Tier 1 screening criteria are classified as potential contaminants of concern and will be considered in the Tier 2 assessment.

Potential Source	Area	Potential Pathway	Potential Receptor	Method of Assessment	Justification
Combustible Shallow Soils	Coal Stockyard	Risk in event of fire	Future residential site users.	Screening undertaken using ICRCL value.	No fate transport modelling required.
Gasworks contamination impact within soils and groundwater including DNAPL associated with relic structures and vapours.	Production Area and Stockyard	Direct contact, inhalation and ingestion and exposure to harmful vapours from soil and groundwater.	Future residential site users	EA CLEA Model v1.07.	Allows a deterministic assessment of human health risk considering a residential scenario.
	Site	Drainage using site infrastructure.	Lineside Dyke	No modelling available, flow unclear and impact may be residual.	
	Southern Area	Migration through the underlying bedrock.	Lineside Dyke	No viable linkage. Cyanide impact in groundwater considered localised and perched.	
	Portion of the Process Area	Migration through the underlying sandstone	Lineside Dyke	EA's Remedial Targets Worksheet v3.2	Enables a fate – transport model assessment of contamination onsite, allowing a calculation of target concentrations protective of a fixed downgradient compliance point using contaminant and aquifer specific input parameters.
Gasworks and Stockyard Contamination impact within soils and groundwater, including metals	Production and Stockyard Area	Migration through the underlying sandstone.	Secondary A Aquifer Northern Plume		
Asbestos in made ground	Production and Stockyard Area	Direct contact, ingestion and inhalation.	Future residential site users	JIWG. Decision Support Tool for Qualitative Risk Ranking. V2. 2017	Allows screening of asbestos risk in accordance with CLR 11 requirements. In line with SoBRAs Conceptual Framework for Asbestos Risk Assessment and Control (2015).

Table 3: Model Selection

A Tier 2 assessment will take into consideration site specific parameters which make up each pollutant linkage and use this to determine Site Specific Assessment Criteria (SSAC). SSAC represent maximum concentrations, in excess of which contaminants may pose a hazard to the identified receptor.

6.0 Combustible Soils

Samples of soils taken predominantly from the Breeze deposit across the Coal Stockyard were analysed for calorific value to determine the risk posed by combustion of this material. This is compared directly to ICRCL guidance (ICRCL 61-84. 1986. Notes on the Fire Hazards of Contaminated Land). This states that, '...materials whose calorific values exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn. Within this range, there is likely to be a large number of potentially combustible materials'.

The results ranged from 8MJ/kg to 25mg/kg which is indicative of combustible material, however, coal breeze had been scraped back and stockpiled in the northern part of the stockyard and thicknesses of breeze across the site was minimal with a maximum thickness of 0.4m located at TP55 in the west.

As such Geo² consider all black, breeze material to be of sufficient calorific value to either be considered flammable or to be capable of sustaining a fire. This material may pose a risk through geotechnical or structural damage or risk to human health in the event of a fire. The distribution of this material has been well defined by the investigation programme.

7.0 Human Health Risk Assessment

The proposed development of the site as a residential estate indicates that a residential model, assuming plant uptake, should be adopted as the basic scenario for this model.

It is acknowledged that the final levels of the site are anticipated to increase as part of the proposed establishment of site levels to match the surrounding landscape. However, at the time of writing final levels have yet to be established. Additionally, it is anticipated that in certain portions of the Production Area, land levels are unlikely to change significantly. As such this model will work with a shallow soil source, present within the top metre of soil. The values produced will be suitable for assessing the quality of the soils for use as subsoil in the proposed development.

Due to the depth to groundwater, and based on results of soils testing, this assessment assumes that the key source of volatile vapours will be the shallow soils (with particular relevance to observed contamination in the former Benzole Plant area).

7.1 CLEA Input Parameters

Given the site's proposed use, the CLEA parameters associated with residential land use have been adopted in the model. The input parameters utilised in the CLEA model are detailed in Tables 4 below.

Receptor	Residential Receptor
Exposure Pathway	Assumed exposure with direct contact and ingestion of shallow soils and dusts, exposure to vapour both indoor and outdoor. This includes the impact of consumption of homegrown veg.
Receptor Type	Most sensitive assumption (female) has been used based on a young child (1-6yrs) in a residential scenario with gardens. Based upon the proposed site development plan the default values for a semi-detached property have been assumed. The development proposed a mix of detached and semi, however, semi is the most common development type.
Exposure Environment	In the absence of specific detail regarding the construction of the neighbouring property the default inputs (SR3) for a semi-detached property have been adopted. Due to the potential for migration it has been assumed that the property directly overlies the impact (the CLEA model does not allow for fate – transport modelling of the plume).
Substrate	SR3 default values have been used to represent the underlying soils. pH and SOM based on site data.
Contaminants of Concern	Assessment undertaken on compounds found to exceed the GAC. Where suitable data is unavailable compounds have been assumed not to be risk drivers. Benzo (a) pyrene has been adopted as an indicator for PAH compounds as the key risk driver.
Generic Inputs	Default assumptions for chemical parameters and receptors have been adopted.

Table 4 CLEA Input Parameters

7.2 Onsite Human Health Risk: Soils

The following assessment produces target values for comparison to soil concentrations recorded onsite. Concentrations of determinands found to exceed these limits should be considered to represent a potentially unacceptable risk to proposed users or to the suitability of materials for use in the proposed residential development.

The CLEA model worksheets, and relevant input parameters used in the derivation of the values below, have been included in Appendix C. A summary of the outputs based on the combined Soil Assessment Criteria is provided in Tables 5a to 5c.

Determinand	Tier 2 Site Specific Assessment Criteria (mg/kg)	Impact Locations
Metals		
Arsenic	37.1	N
Beryllium	72.6	N
Lead	201	Stockyard: TP95 (0.2m) 237mg/kg Production Area: BH19-03 (1m) 365mg/kg BH19-07 (0.5m) 584mg/kg TP9 (0.1m) 509mg/kg TP10 (0.2m) 204mg/kg
Mercury	1.2mg/kg (GAC value adopted)	Stockyard: TP88 (0.2m) 1.23 mg/kg Production Area: TP10 (0.2m) 9.66mg/kg TP27 (1m) 24.9mg/kg TP28 (0.5m) 1.43mg/kg TP45 (0.3m) 17.9mg/kg TP49 (0.5m) 3.67mg/kg BH19-03 (1m) 12.7mg/kg BH19-07 (0.5m) 2.21mg/kg
Nickel	590	N
Chromium	910 (GAC value adopted)	Production Area: TP32 (0.5m) 6,340mg/kg TP45 (0.3m) 1,210mg/kg
Phenol	899	Production Area: TP26 (1m) 1,090mg/kg
PAH		
Benzo (a) pyrene	4.96	Coal Stockyard: TP61 (1.2m) 13.7mg/kg Production Area: TP26 (1m) 658mg/kg TP42 (1m) 152mg/kg TP45 (0.3m) <50mg/kg WS20-07C (0.2m) 971mg/kg BH19-02 (0.5m) 9.4mg/kg BH19-07 (0.5m) 20mg/kg
Naphthalene	40.7	Coal Stockyard: TP61 (1.2m) 940mg/kg Production Area: TP26 (1m) 8530mg/kg TP42 (1m) 2710mg/kg TP45 (0.3m) 429mg/kg WS20-07C (0.2m) 1600mg/kg BH19-02 (0.5m) 82.5mg/kg, (7m) 62.5mg/kg BH19-05 (13.5m) 55.5mg/kg BH19-07 (0.5m) >2180mg/kg

Table 5a Human Health SSAC (Soils)

Determinand	Tier 2 Site Specific Assessment Criteria (mg/kg)	Impact Locations
VOC / SVOC		
2-Methylnaphthalene	58	Coal Stockyard:TP61 (1.2m) 358mg/kg Production Area:TP26 (1m) 1950mg/kg TP42 (1m) 7610mg/kg TP45 (0.3m) 1500mg/kg WS20-07C (0.2m) 1770mg/kg BH19-02 (0.5m) 261mg/kg BH19-07 (0.5m) 62.6mg/kg
2- Methylphenol	342	Production Area:TP26 (1m) 581mg/kg
Carbazole	NA	N
1,2,4-Trimethylbenzene	6.36	Production Area:TP26 (1m) 6.91mg/kg
2,4- Dimethylphenol	210 (GAC value adopted)	Production Area:TP26 (1m) 437mg/kg
Benzene	0.42	Production Area:TP26 (1m) 113mg/kg TP42 (1m) 14.7mg/kg WS20-07C (0.2m) 4.89mg/kg BH19-02 (0.5m) 1.29mg/kg BH19-05 (13.5m) 0.65mg/kg BH19-07 (0.5m) 61.8mg/kg
Toluene	489	N
Ethylbenzene	268	N
Xylenes m-p	161	N
Xylenes -o	174	N
TPH		
Aliphatic >C8-C10	74.7	Production Area:TP42 (1m) <1250mg/kg BH19-07 (0.5m) 128mg/kg
Aliphatic >C10-C12	373	Production Area:TP26 (1m) 711mg/kg TP32 (0.5m) 584mg/kg TP42 (1m) <1250mg/kg
Aromatic >C5-C7	233	N
Aromatic >C7-C8	489	N
Aromatic >C8-C10	110	Production Area:TP26 (1m) 7,170mg/kg TP28 (1m) 1,400mg/kg TP32 (0.5m) 2,820mg/kg TP33 (1.1m) 377mg/kg TP42 (1.0m) 1,820mg/kg TP45 (0.3m) 475mg/kg TP48 (1.3m) 411mg/kg WS20-07C (0.2m) 1,740mg/kg BH19-02 (0.5m) 361mg/kg BH19-07 (0.5m) 4,950mg/kg
Aromatic >C10-C12	290	Coal Stockyard:TP61 (1.2m) 4640mg/kg Production Area:TP26 (1m) 109,000mg/kg TP28 (1m) 36,700mg/kg TP32 (0.5m) 28,500mg/kg TP33 (1.1m) 3,470mg/kg TP42 (1.0m) 26,600mg/kg TP48 (1.3m) 21,200mg/kg WS20-07C (0.2m) 19,700mg/kg BH19-02 (0.5m) 4690mg/kg + (7m) 377mg/kg BH19-07 (0.5m) 12,500mg/kg

Table 5b Human Health SSAC (Soils)

Determinand	Tier 2 Site Specific Assessment Criteria (mg/kg)	Impact Locations
TPH		
Aromatic >C12-C16	545	Coal Stockyard: TP61 (1.2m) 23,900mg/kg Production Area: TP10 (0.2m) 872mg/kg TP21 (3m) 1,100mg/kg TP26 (1m) 91,700mg/kg TP28 (1m) 34,800mg/kg TP32 (0.5m) 38,800mg/kg TP33 (1.1m) 1,790mg/kg TP42 (1.0m) 71,600mg/kg TP45 (0.3m) 63,700mg/kg TP48 (1.3m) 12,100mg/kg WS20-07C (0.2m) 23,600mg/kg BH19-02 (0.5m) 19,900mg/kg + (7m) 1,950mg/kg BH19-07 (0.5m) 9,230mg/kg
Aromatic >C16-C21	809	Coal Stockyard: TP61 (1.2m) 4780mg/kg Production Area: TP10 (0.2m) 2020mg/kg TP21 (3m) 1,350mg/kg TP25 (1.5m) 931mg/kg TP26 (1m) 105,000mg/kg TP27 (1m) 2,050 mg/kg TP28 (1m) 39,000mg/kg + (0.5m) 1,470mg/kg TP29 (0.5m) 1,590 mg/kg TP32 (0.5m) 30,900mg/kg TP33 (1.1m) 4,680mg/kg TP42 (1.0m) 41,300mg/kg TP45 (0.3m) 22,600mg/kg TP48 (1.3m) 2,290mg/kg WS20-07C (0.2m) 22,000mg/kg BH19-02 (0.5m) 19,900mg/kg + (7m) 1,950mg/kg BH19-07 (0.5m) 9,230mg/kg
Aromatic >C21-C35	1,660	Production Area: TP21 (3m) 1,890mg/kg TP25 (1.5m) 2,760mg/kg TP26 (1m) 101,000mg/kg TP27 (1m) 4,390 mg/kg TP28 (1m) 24,600mg/kg+ (0.5m) 4,240mg/kg TP29 (0.5m) 3,260 mg/kg TP32 (0.5m) 24,900mg/kg TP42 (1.0m) 12,800mg/kg TP45 (0.3m) 2,040mg/kg WS20-07C (0.2m) 19,100mg/kg

Table 5c Human Health SSAC (Soils)

Table 5 indicates that the concentrations of contamination within the subsoils in the Stockyard area include sporadic hotspots of elevated hydrocarbons and metals associated with variable made ground and an identified relict structure (with evidence of tarry waste) in TP61.

The production area exhibits areas of significant impact associated with key point sources typically in the Benzole and Storage tank areas, however additional elevated concentrations are associated with samples from across the wider area, which exhibit evidence of contamination associated with and within relic infrastructure.

The South Area is free from identified contamination which might pose an unacceptable risk to human health.

8.0 Controlled Waters Risk

This section models the risk to the Secondary A Aquifer and Lineside Dyke from migration of contaminants through the subsurface.

8.1 Remedial Targets Methodology

A detailed quantitative risk assessment (QRA) was undertaken to assess the potential risk from impacted soils and impacted groundwater to the compliance point.

The QRA of controlled waters is designed to generate site specific assessment criteria (SSAC), for comparison with the soil and groundwater results to ensure that controlled waters are not adversely affected by any future migrating plume of contamination.

The Remedial Target Worksheets (v3.2) have been used to achieve this purpose by characterising a simplified conceptual model designed to predict migration of contaminants through the soils towards the receptor.

Site data gathered from laboratory analysis, site testing and logging records, together with published data, has been used to define parameters to assess the soil and groundwater beneath the site.

Modelling of the contamination was assessed on three levels which take into account distances to compliance points and different assumptions about the attenuation of contaminants. The three levels of assessment for the derivation of soil remedial targets and their assumptions are briefly described as follows:

- Level 1 soils – compliance point is taken as the soil zone. There is no allowance for processes such as dilution or attenuation which might affect contaminant concentrations along the pathway between the site and receptors. At Level 1 the soil remediation target is equal to a calculated soil concentration as only soil data (as opposed to soil leaching data) is available. The empirical equations calculated by the model describe soil-water partitioning and are therefore sensitive to the value of the partition coefficient.
- Level 2 soils – considers how dilution of contaminants leached from soil by groundwater flow below the site and attenuation of pollutants within unsaturated zone are sufficient to reduce contamination concentrations to acceptable levels.
- Level 3 soils and groundwater - considers whether attenuation of pollutants down-hydraulic gradient of the source is sufficient to reduce contaminant concentrations to acceptable levels. This is the level Geo² use to determine site specific assessment criteria (SSAC). The laboratory results can be compared with groundwater, soil or pore water (leaching) results obtained from the site.

The output SSAC at each of the levels provides a remedial target for on-site contamination from the most conservative (Level 1) to the most realistic, site specific assessment criteria (SSAC) (Level 3).

8.2 Input Parameters

Full details on the assumptions used in the model are shown on the Input and Output 'Master Sheet', which are presented in Appendix C (model worksheets).

8.2.1 Compliance Point

The RTM guidance states that, 'if the contaminant is a List 1 ['hazardous'] substance (i.e. one whose entry into groundwater must be prevented), then the base of the unsaturated zone should be set as the compliance point'. This means that the output of Level 2 of the RTM would be the target concentration.

Geo² consider that given contamination has been identified within the groundwater, use of this target is unfeasible and as such a Tier 3 assessment, requiring use of a downgradient compliance point will be undertaken.

Current guidance, obtained from the Gov.uk website states the following about compliance points:

Use compliance points within a risk assessment and remedial strategy to protect receptors from a source of contamination.

The compliance point is the point along the groundwater flow pathway where the defined target concentration (compliance limit or value) must not be exceeded. The compliance point may:

- be the receptor itself.***
- be a specified point along the source–pathway–receptor linkage, for example within the aquifer between the source and receptor.***
- represent pore water in the soil zone.***

The location of the compliance point will depend on the circumstances, the level of assessment and the sensitivity of the receptor.

The compliance point may be a virtual point for the purpose of predictive assessments (modelling) or it may be a physical monitoring point, for example a borehole or spring.

The default compliance point distance for resource protection from the contaminant source is 50 metres for:

- all hazardous substances in all aquifers for contaminants already in the groundwater, or from inputs from soils and the unsaturated zone which can't be prevented.***
- non-hazardous pollutants in groundwater with strategic resource potential.***

Resource protection where there is existing groundwater contamination

Where there is existing groundwater contamination, your aim is to avoid contaminant plumes extending beyond the 50 or 250 metre distances. This is measured from the boundary of the original pollutant source. If your hydrogeological risk assessment indicates this has or may occur, you must investigate, assess and if necessary, take remedial action to:

- reduce the source term***
- stabilise the migrating front of the plume***
- reduce the expansion of the plume***

If there is a specific receptor (for example a borehole, spring or river) located closer to the source than the 50-metre distance, use that specific receptor as your compliance point.

The following contaminants of concern, selected for this analysis by virtue of their present in groundwater samples in concentrations in excess of appropriate GAC contaminants are considered as hazardous and non-hazardous (UK TAG, Water Framework Directive):

- **Hazardous Pollutant:** All hydrocarbon fractions and BTEX compounds, Benzo (a) pyrene (the selected indicator for PAH compounds), Arsenic and Lead.
- **Non-Hazardous Pollutant:** Cyanides, Nickel, Selenium, Phenols.

Hazardous pollutants will use a 50m compliance point in this assessment. Non-hazardous pollutants will use a 300m compliance point which is the distance from the centre of the impact, in the production area, to the northerly site boundary (down hydraulic gradient). When considering the risk to the Lineside Dyke, a compliance point of 50m will be selected for all contaminants to reflect the proximity of this waterbody (approximately 50m from the significant impact in the west of the Production Area).

Geo² have used the target values calculated on Level 3 of the RTM worksheets to model the risk of contaminants leaching through soils, and from groundwater bound contaminants, to off-site controlled waters.

8.2.2 Degradation Rates

The model uses an assessment of contaminant degradation to aid in fate transport modelling. Selection of appropriate values is drawn from literature values (e.g. Howard et al) and influenced by site data to aid in determining whether degradation is occurring and at what rate.

Analysis undertaken during the Site Investigation includes geochemical parameter data, which may be used to provide evidence in support of groundwater degradation (guidance drawn from Appendix 2 of Environment Agency, R+D Publication 95).

Geochemical Parameters in Sandstone	NO	Max	Min	Avr.	Role in Nat Attenuation Assessment	Interpretation	Aerobic (Y/N)
pH (w)	8	8.28	3.72	7.13	Microbial activity tends to be reduced outside of a pH range of 6 to 8.5, and many anaerobic bacteria are particularly sensitive to pH extremes.	Data mainly falls in aerobic degradation range.	Y
Redox Potential (w)	7	238	60.3	179	A measure of the oxidation / reduction potential of the environment. Typical ranges from +800mV in strongly aerobic conditions to -400mV under methanogenic conditions.	Conditions appear slightly oxidising, suggesting aerobic conditions.	Y
Electrical conductivity @ 20degC (w)	7	7290	1551	3558	General water quality parameter, used as a marker to verify that site samples are obtained from the same aquifer system.	Data range indicates connectivity between all wells installed into the sandstone, including the deep BH305.	
Ferrous iron FeII (w)	5	4.4	<0.01	0.92	Indication of Fe(III) reduction during microbial degradation of organic compounds in the absence of oxygen, nitrate and manganese (IV).	Concentration are considered low, which does not suggest aerobic depletion.	Y

Table 6a Geochemical Indicators

Geochemical Parameters in Sandstone	NO	Max	Min	Avr.	Role in Nat Attenuation Assessment	Interpretation	Aerobic (Y/N)
Ferric iron FeIII (w)	4	8.5	0.1	1.8	Biologically available Fe(III) can act as an electron acceptor during anaerobic degradation of organics.	Predominantly low values suggests aerobic conditions across most of the site. Elevated in BH19-06, in impacted groundwater, suggests localised O ² depletion may be occurring.	Y local exceptions may occur
Manganese IV (w)	7	2400	130	1196	May act as an electron acceptor during anaerobic degradation of contaminants where more thermodynamically favourable electron acceptors are absent.	Concentration appear significantly elevated, likely due to land contamination. Difficult to gauge significance in terms of degradation.	-
Manganese II (w)	7	18000	120	7440	Indicator of anaerobic degradation of organics, where manganese (IV) acts as an electron acceptor.	Concentration appear significantly elevated, likely due to land contamination. Difficult to gauge significance in terms of degradation.	-
Nitrite (w)	7	3.7	1.5	2.78	Product of nitrate reduction. Produced under anaerobic conditions. Rarely observed.	Limited observed.	Y
Nitrate (w)	7	216	4.8	84.5	Thermodynamically next favourable electron acceptor after oxygen for microbial degradation. Depletion may indicate anaerobic degradation of organics.	Average in UK is 38mg/l (BGS), highly exceeded here, with no clear evidence of depletion.	Y

Table 6b Geochemical Indicators

On this basis Geo² consider aerobic degradation within the subsurface to be occurring, and this assessment assumes mid-range literature values for aerobic degradation (where appropriate).

Geo² noted that in applying 'degradation rates to dissolved phase only', the rates of degradation calculated by the model were slower than when the rates extended to pollutants in all phases.

Modelling of the groundwater contamination will take into account the potential attenuation as contaminated groundwater moves off-site to the receptor. The Level 3 remedial target concentrations for groundwater are derived by multiplying the target concentrations at the compliance point by the attenuation factor.

Observed contaminant concentrations within the plume of contaminated groundwater have been compared with the remedial targets to assess whether the decay factor applied by the model can reasonably be applied to the site.

8.2.3 Aquifer Characteristics

This model assumes that migration will occur solely within the underlying sandstone, as the groundwater is located within this bedrock, the aquifer is the most likely route for contaminant migration in the water bearing strata.

Where flow appears governed by the underlying sloping mudstone this assessment uses a mid-range hydraulic conductivity value (produced by onsite testing, as detailed in the Site Investigation report) of 2.6m/day

A potential for dual porosity has been suggested associated with observed fracturing within the rock. To reflect this the assessment of the impact to Lineside Dyke, where flow is likely to be impacted by the railway cutting and topography, a worst case hydraulic conductivity value of 4.45m/day will be adopted.

Where possible site-specific input parameters are used, however some parameters relating to the nature of this aquifer are drawn from literature sources for parameters such as effective porosity and bulk density (CONSIM). Infiltration (MET Office - weather station data) is assumed to occur at 1% of rainfall to factor in run off, drainage and evaporation.

The hydraulic gradient was calculated using the survey data for the site. Using Figure 6, in Appendix A, the gradient for the groundwater sloping to the north is calculated as 0.04, whereas the slope to Lineside Dyke is calculated at 0.08, based on observed watermarks in the railway cutting along the western boundary.

8.2.4 Contaminant Specific Parameters

All contaminant inputs are based on literature values drawn from the EA SR7 document, LQM report, CLEA database, TOXNET and Howard *et al.*

8.2.5 Default Assumptions

The model contains a number of default assumptions which assume a Steady State Scenario, this effectively assumes an ongoing release is occurring at the site, and this approach reduces the impact of natural retardation within the aquifer.

Geo² consider that this represents an overly conservative assessment, considering the limited evidence of widespread plume formation at the site, this suggests a higher degree of retardation than would be modelled under the default assessment. In order to ensure this characterisation remains appropriate to consider the risk not just to the current site condition but for the future, a value of 1,000,000 days has been selected (circa 2,740 years).

In this QRA, it is currently not considered appropriate to reduce the time-variant from the model default unless there is adequate justification.

Another model assumption is that it assumes that degradation will only occur in the dissolved phase; this assumption thereby artificially limits the effect of natural degradation of the source zone. In this model these conservative assumptions have been retained.

8.2.6 Risk Drivers

Risk drivers at the site are those compounds which represent the greatest perceived risk by virtue of their mobility, volatility and toxicity.

Hydrocarbons with a low aqueous solubility ($\mu\text{g/l}$) generally have a high retardation coefficient and move very slowly in the subsurface: as such they tend to be unlikely to present a risk to controlled waters. In line with EA guidance, *Petroleum Hydrocarbons in Groundwater: Supplementary Guidance for Hydrogeological Risk Assessment* (2009), aliphatic hydrocarbons $>\text{C}_{12}$ and aromatic hydrocarbons $>\text{C}_{21}$, which demonstrate a low solubility are not considered to present a risk to controlled waters and will not be considered further in the Tier 2 assessment.

Benzo (a) Pyrene has been selected as a key risk driver from the US-EPA PAH compounds. Compound specific parameters for indicator PAH are used as surrogate values for hydrocarbon fractions where relevant.

Where compounds have no appropriate GAC or Environmental Quality Standards these compounds will not be assessed.

8.3 Model Limitations

The RTM does not model the risk from any NAPL or dissolved phase impact migrating via the preferential pathways identified, such as through service runs, and as such it is not possible to use this mechanism to assess flow to Lineside Dyke through former infrastructure.

8.4 Model Outputs

This section displays the SSAC produced to be protective of Lineside Dyke and the Secondary A aquifer.

Full details on the assumptions used in the model, and the model worksheets, are presented in Appendix D.

8.4.1 SSAC Lineside Dyke

These values are derived for comparison with groundwater data arising from locations in the watershed of Lineside Dyke, the area indicated on Figure 6 in Appendix A.

These SSACs are proposed as the site-specific remedial targets to assess groundwater conditions. The derived remedial targets are shown in Table 7 below.

Determinand	Soils	Groundwater
	Remedial Targets – Leaching (from L3 Soils) (mg/kg)	Remedial Targets – Groundwater (from L3 groundwater) (mg/l)
Benzene (or Aromatic C5-C7)	No Impact	No Impact
Toluene (or Aromatic C7-C8)	173	1.77
Mixed Xylenes (or Aromatic C8-C10)	1,490	2.39
Aromatic C10-C12 (Naphthalene)	450	0.459
Aromatic C12-C16	1,140	0.584
Aromatic C16-C21	2,630	0.423
Aromatic C21-C35	2,490,000	0.392
Aliphatic C10-C12	450	0.257
Aliphatic C12-C16	1,140	No Impact
Benzo (a) pyrene	No Impact	0.000732
Cyanide	102	10.6
Thiocyanate	102	10.6
Arsenic	701	0.204
Lead	No Impact	No Impact
Nickel	167	979
Selenium	0.813	1.2
Phenol	4.84	447,000,000

Table 7: SSAC for the Lineside Dyke Catchment

The calculated remedial targets in Table 7 present the maximum concentrations of determinands which would ensure that neither the soil-bound or groundwater-bound contamination would impact at the Lineside Dyke (L3 soils and groundwater).

Concentrations of contaminants are found to pose a plausible risk to the Lineside Dyke through:

- Migration within the groundwater: BH19-01, BH19-02, BH19-05, BH19-06, BH19-07.
- Leaching from Impacted Shallow and Unsaturated soils: TP9 (0.5m), TP10 (0.2m), TP22 (1m), TP42 (1m), TP45 (0.3m), TP48 (1.3m), WS20-07C (0.2m), BH19-02 (0.5m + 7m), BH19-03 (1m), BH19-07 (0.5m).

Plans showing the locations of gross soil and groundwater contamination are presented in Figures 9 and 10 in Appendix A.

8.4.2 SSAC Northern Plume

These values are derived for comparison with groundwater data arising from locations in the watershed of Lineside Dyke, the area indicated on Figure 6 in Appendix A.

These SSACs are proposed as the site-specific remedial targets to assess groundwater conditions. The derived remedial targets are shown in Table 8 below.

Determinand	Soils	Groundwater
	Remedial Targets – Leaching (from L3 Soils) (mg/kg)	Remedial Targets – Groundwater (from L3 groundwater) (mg/l)
Benzene (or Aromatic C5-C7)	No Impact	No Impact
Toluene (or Aromatic C7-C8)	101,000	3730
Mixed Xylenes (or Aromatic C8-C10)	633,000	3450
Aromatic C10-C12 (Naphthalene)	217,000	0.755
Aromatic C12-C16	889,000	1.57
Aromatic C16-C21	2,450,000	0.591
Aromatic C21-C35	No Impact	0.776
Aliphatic C10-C12	No Impact	3.71
Aliphatic C12-C16	No Impact	No Impact
Benzo (a) pyrene	No Impact	0.00148
Cyanide	680	10.6
Thiocyanate	680	10.6
Arsenic	1,590,000,000	0.204
Lead	No Impact	No Impact
Nickel	No Impact	979
Selenium	419	1.2
Phenol	4.84	0.33

Table 8: SSAC for the Secondary A Aquifer Catchment

The calculated remedial targets in Table 17 present the maximum concentrations of determinands which would ensure that neither the soil-bound or groundwater-bound contamination would impact at the Lineside Dyke (L3 soils and groundwater).

Concentrations of contaminants are found to pose a plausible risk to the Secondary A Aquifer through:

- Migration within the groundwater: Tar sump, BH305 (marginal exceedance).
- Leaching from Impacted Shallow and Unsaturated soils: No reported exceedances.

Plans showing the locations of gross soil and groundwater contamination are presented in Figures 9 and 10 in Appendix A.

The remedial targets calculated by the RTM can be used to assess any unexpected dissolved phase contamination identified during future excavations or within the underlying aquifer.

9.0 Asbestos Risk

Screening and identification of the asbestos identified the presence of Chrysotile and Amosite within two of the eleven samples tested in the stockyard, and three of the five samples tested in the production area. The encountered asbestos is detailed on Table 9, below.

Location	Depth	Type	%	Quantity (JIWG, 2012 Classification)
TP53- Stockyard	0.3m	Chrysotile fibres	<0.001	Trace
TP69- Stockyard	0.7m	Chrysotile fibres	0.127	Large
TP23- Production Area	1.0m	Chrysotile fibres	<0.001	Trace
TP28- Production Area	0.5m	Amosite fibres	<0.001	Trace
BH19-03- Production Area	1.0m	Amosite and Chrysotile board and fibres	0.017	Low

Table 9: Identified Asbestos

Data suggests a sporadic and infrequent distribution of asbestos across the Stockyard area, where it may be encountered within the made ground. With three of five samples in the Production Area encountering asbestos within the made ground, Geo² consider this to be likely much more widely distributed in this area.

The results obtained from the laboratory screening and volumetric analysis allows the site risk to be evaluated and characterised in accordance with the JIWG Decision Tool for Receptor Risk Ranking, Asbestos in Soil and Construction & Demolition Materials (JIWG., 2012). The project specific spreadsheets used to for determine the risk to receptors posed by asbestos on site are included in Appendix E.

Project specific details and risk factors were used in the spreadsheet to characterise and evaluate the risk to site users assuming redevelopment of the property as detailed in this report, should this material remain within shallow soils. This has particular relevance for the Production Areas where levels of upfilling are expected to be minimal. This assessment does not address construction workers during development.

Table 10, overleaf, shows input values based on a future residential development, where this material has remained within the subsoils. This uses conservative data from the site investigation, considering the distribution, number of samples and observed fibre counts.

	Stockyard	Production Area
ACM Type	Free dispersed fibres	Free dispersed fibres
Degradation	Disaggregated	Disaggregated
Friability or bonding	Free dispersed	Free dispersed
Distribution	None visible	None visible
Fibre Type	Chrysotile alone	Mainly Amosite
Calculated Hazard	Low	Medium
Fibre Amount	Very low	Low
Respirable Index	Very low	Very low
Activity Type	Moderate disturbance (redevelopment works)	Moderate disturbance (redevelopment works)
Host Material	Made ground	Made ground
Exposure Rating	Low	Medium
Receptor	Residential	Residential
Age	Infant (worst case)	Infant (worst case)
Duration	24hrs residential exposure	24hrs residential exposure
Receptor Ranking	High	High
Receptor Distance	Within 10m	Within 10m
Impact Depth	Material present at depth	Material present at shallow depth
Pathway Ranking	Very Low	Low
Overall Ranking	Very Low	Low

Table 10: Asbestos Risk

Asbestos material is considered to be a low to very low risk to a future residential end use, where this material remains buried in the subsurface at identified concentrations.

10.0 Risk Estimation

Site investigation has encountered a range of contaminants present within soils and groundwater following the use of the site of a colliery and coking works. Detailed risk assessment has allowed each of the relevant pollutant linkages identified to be quantitative or qualitatively assessed to determine the risks posed to the proposed future residential use of the site.

Due to the nature of the contaminant distribution at the site this has comprised the use of a range of techniques to determine the extent and severity of the contamination and to aid determination of maximum safe concentrations to ensure risks to human health and the environment can be minimised.

11.1 Production Area Significant Contaminant Distribution

The gross impact at the site can be divided into three key areas; namely principal source, secondary source and tertiary source.

This applies to the chemical contamination associated with the Production Area, where the majority of the impact was encountered and does not address soils of high calorific value.

10.1.1 Principal Source Zone

The principal source area, typified by shallow tarry contamination within and around concrete infrastructure and foundations, including gross tar sumps (full- near TP24) across much of the Production Area. This impact has predominantly used the preferential pathways and natural sumps within the infrastructure to become distributed across the area illustrated on Figure 11, in Appendix A.

This impact predominantly remains within the top 1-2mbgl and comprises significantly elevated cyanide (peak values of 7,880mg/kg), metals (a reported peak of 6,340mg/kg chromium), PAH (peak 18,000mg/kg total USEPA 16), hydrocarbons (peak 432,000mg/kg) and phenols (peak of 1,090mg/kg). This material poses a risk to human health (should it remain in shallow soils) and poses a leaching risk to the groundwater allowing for further ongoing contamination of controlled waters.

Geo² consider that the Principal Source Zone comprises the bulk of the contaminant mass at the site.

10.1.2 Secondary Source Zone

In the most significantly impacted areas, the contamination has penetrated vertically beyond the surface infrastructure and entered the made ground and unsaturated zone where it forms substantial contaminant mass. Laterally restricted into the Benzole Plant and Storage Tank Areas of the Production Area of the site, as show on Figure 11 in Appendix A, this impact has penetrated to a greater depth. The area of impact comprises made ground and underlying shallow sandstone bedrock, where it is likely that the dual porosity allows for contamination to remain within fractures and fissures.

Due to the manner of sampling and drilling very little sample data is available beyond logging, however its presence can be inferred by the presence of deeper contamination within the groundwater.

10.1.3 Tertiary Source Zone

Groundwater samples have reported significantly elevated concentrations of PAH (11mg/l peak in BH19-05), phenol (peak of 67mg/l in BH19-05) and hydrocarbons (reported to be

1,000mg/l in BH19-07). Cyanides and Thiocyanate was reported in excess of target levels protective of Lineside Dyke in BH19-02, BH19-03, BH19-04 and BH19-06. Concentrations of PAH are suggestive of the presence of DNAPL in this area, although this has not been clearly identified in boreholes.

This impact appears to be present within groundwater in the underlying sandstone where, due to the proximity of the Lineside Dyke and railway cutting, the local hydraulic regime has been altered to cause this impact to migrate westerly, rather than follow the regional trend to the north. Whilst a clear path for migration has not been demonstrated, it must be assumed that a portion of this impact is contributing to the observed impact in the Lineside Dyke.

The underlying mudstone present across the site and at an approximate depth of 16m below ground level in this area is considered likely to act to prevent further vertical migration.

Groundwater in the Production Area does not appear to be presenting a risk to the Secondary A aquifer; although sampling from BH305, a deeper well installed historically into an underlying sandstone body, does indicate a slight exceedance of one hydrocarbon fraction (although Geo² consider there to be a risk of cross contamination to the well).

10.1.4 Other Hotspots and Diffuse Impacts

Aside from the substantial key contaminant impacts detailed above, numerous isolated or sporadic samples were noted to exceed derived target values.

Where human health values are exceeded (such as metals in TP51, TP61, TP88 and TP95 in the coal stockyard), this should be considered in respect of the final development strategy, where these soils will not be present in the top meter of subsoils, then this material need not be removed or treated.

10.2 Coal Stockyard Impact

The mantle of breeze present across the Stockyard area is considered to be combustible in its entirety, as such this is considered to require removal to facilitate redevelopment.

Aside from localised concentrations of asbestos and metals, the coal stockyard appears predominantly free from significant contamination. With notable hotspots associated with former infrastructure and buried concrete located in the west of the area around TP61 (PAH 16 recorded at 4,250mg/kg) and TP80 (where visual evidence of tars was reported).

The subsequent remedial strategy should aim to target these hotspots.

10.3 Southern Area Impact

Data from the southern area encountered low levels of contamination. The groundwater in this area appeared localised within low permeability deposits overlying the natural mudstone and is considered perched.

As such residual concentrations of contaminants are considered to require no further mitigation.

It should be noted that the Biological Treatment Plant infrastructure remains in this area, which required demolition.

10.4 Infrastructure Pathways

Monitoring has been undertaken from the Lineside Dyke, which demonstrates contamination significantly in excess of the Environmental Quality Standards (EQS). Geo² consider that the majority of this impact is related to relict drainage infrastructure from the site, associated with the principal contaminant source.

Geo² consider it likely that the concentrations noted may contribute to this observed impact although it is considered that the regional quality of this beck is likely to be poor, based upon upstream samples and sampling upstream in the nearby Wakefield Brook.

10.5 Risk from Asbestos in Made Ground

JIWG assessment of asbestos in made ground considers this to present a low risk to future site users. However, it would be prudent to consider the potential for this material to be present when considering reuse of any material in shallow soils (<1m below finished garden / floor level).

10.6 Qualitative Risk Assessment

Based on the findings from this assessment a revised Qualitative Risk Assessment has been produced. Table 11 presents the revised source-pathway-receptor linkages.

Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Combustible Shallow Soils in Stockyard area.	Risk in event of fire	Future residential site users.	High likelihood, breeze material is all considered combustible.	Medium. Fire may cause harm to human health and significant damage to building and property.	High risk.
Gasworks contamination impact within soils and groundwater including DNAPL associated with relic structures and vapours.	Direct contact, inhalation and ingestion and exposure to harmful vapours from soil and groundwater.	Future residential site users	Likely Subject to level increase, much of the soils material across Production Area is unsuitable.	Medium. Should material remain in sub soils this may present a risk to human health.	Moderate Risk
	Drainage using site infrastructure.	Lineside Dyke	High likelihood. Concentrations of contaminants peaks in Lineside Dyke linked to site drainage	Mild. Dyke is of poor quality and low flow (minimal to no flow during summer).	Moderate Risk
	Migration through the underlying bedrock.	Lineside Dyke	Likely. Connection remains unproven however, no barrier to offsite migration.	Mild. Dyke is of poor quality and low flow (minimal to no flow during summer).	Low / Moderate Risk

Table 11a. Revised Qualitative Risk Assessment

Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Gasworks and Stockyard Contamination impact within soils and groundwater, including metals	Migration through the underlying sandstone.	Secondary A Aquifer Northern Plume	Low Likelihood. Limited evidence of plume formation, only, minor SSAC exceedance observed.	Minor. Impact is unlikely to be sufficient to product any meaningful impact to the wider groundwater quality.	Very Low Risk
Asbestos in made ground	Direct contact, ingestion and inhalation.	Future residential site users	Low likelihood. Present intermittently within the Production Area and infrequently in the Stockyard area.	Mild. JIWG assessment of the risk considered there to be Low.	Low Risk

Table 11b. Revised Qualitative Risk Assessment

11.0 Conclusion

This Detailed Quantitative Risk Assessment assesses the significance and extent of land contamination, encountered at the former Monckton Coking Works Facility, Lund Hill Lane, Royston.

This report builds upon the findings of earlier site investigation work and uses numerical modelling techniques to evaluate each of the relevant pollutant linkages, to determine whether unacceptable risks are posed to the human health of future site users and the environment.

The site is broadly divided into three key areas. The northernmost Stockyard area remains surfaced with a thin horizon of black granular 'breeze'; a coal and coke deposit of high calorific value. This deposit, which extends across most of the Stockyard area, is considered highly flammable and unsuitable for retention onsite. Localised hotspots of contamination have been encountered in this area typically associated with relic infrastructure.

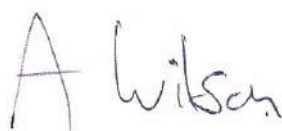
The central portion of the site formerly housed the Coke Ovens and Production infrastructure; assessment indicates that substantial volumes of gross tar and gasworks type contamination remains within shallow made ground and is closely bound up to former infrastructure buried beneath the site. This has been considered to pose a risk to human health and to the underlying groundwater, with a corresponding impact reported in the nearby surface watercourse, Lineside Dyke.

Deeper contamination is also present in the west of this area where gasworks type contamination has vertically migrated into the underlying sandstone, and is indicated to be migrating through fractures and fissures within the rock into Lineside Dyke.

The southern portion of the site contains relatively low concentrations of contaminants, this is not considered to present any unacceptable risk to future use.

This report does not make any assessment of development constraints associated with geotechnical or structural issues.

This report was prepared by



Adam Wilson

29.07.2020

Date

This report was reviewed by



Paul Stapleton

Date

29.07.2020

12.0 Limitations

Geo²'s conclusions, recommendations and opinions are based on information gathered at the time of the investigation from a variety of third party sources and from observations made during site reconnaissance and ground conditions encountered during the field work and on the results of laboratory and field tests performed during the investigation. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata and water conditions between or below intrusive locations. It should also be noted that groundwater levels may vary due to seasonal or other effects and may at times differ to those measured during the investigation.

A portion of this report is based solely upon information provided by third parties. The information has not been independently verified by Geo². Whilst this report and the opinions given in it are accurate to the best knowledge of Geo², Geo² cannot guarantee the completeness or accuracy of any descriptions, opinions or conclusions based solely upon information that has not been independently verified.

The recommendations contained within this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices and hydrological and engineering practices at this time. As such they are not a guarantee that the site is free of hazardous materials or conditions.

Geo² prepared this report for our Client; any third parties using this report do so entirely at their risk. Geo² makes no warranty or representation whatsoever, express or implied, with respect to the use by a third party of any information contained in this report or its suitability for any purpose. Geo² assumes no responsibility for any costs, claims, damages or expenses (including any consequential damages) resulting from the use of this report or any information contained in this report by a third party.

13.0 References

BGS

BGS Geology of Britain Viewer

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Ciria

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CL:AIRE / EIC

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Chemical Standards Database (accessed online) - Workplace exposure limits (WELs) are set under the Control of Substances Hazardous to Health (Amendment) Regulations 2004 (SI 2004/3386).



Geo²

Gap Analysis and Data Review: Former Monckton Coking Works. Ref: 19.B0010.1.2
Environmental Site Assessment: Former Monckton Coking Works. Ref: 20.B0010.4.1

LQM/ CIEH

LQM/CIEH Suitable 4 Use Levels Nathaniel, C.P; McCaffrey, C.; Gillett, A.G.; Ogden, R.C. & Nathaniel, J.F. Land Quality Press, Nottingham 2015

NHBC

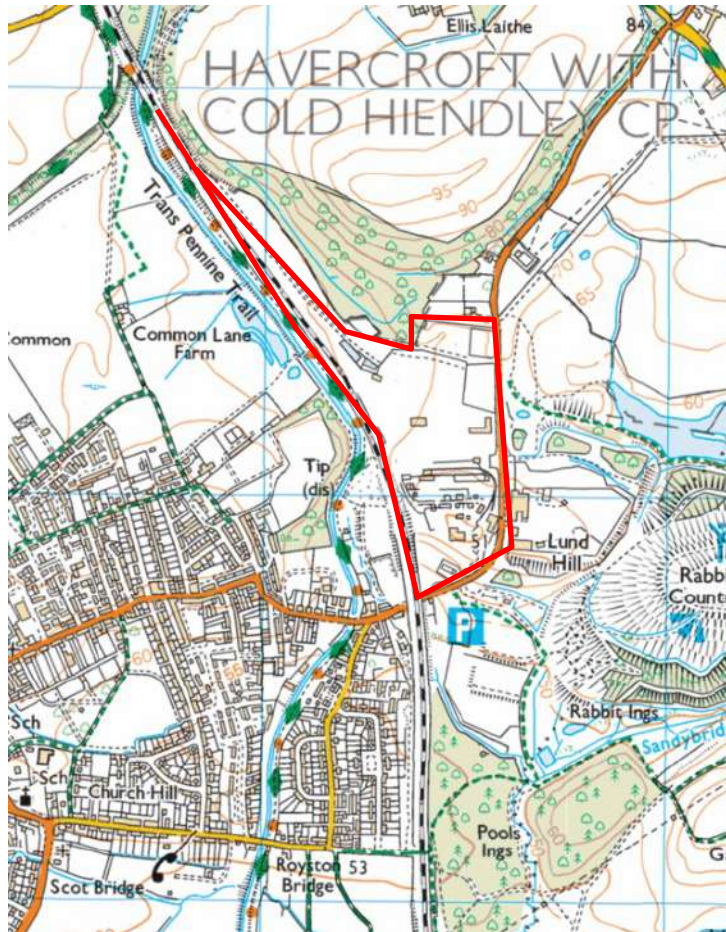
Guidance for Safe Development of Housing on Land Affected by Contamination.
R+D Publication 66:2008

Howard et al

Handbook of Environmental Degradation Rates, 1991

Appendix A

Figures



Ref: Ordnance Survey



Figure 1 Site Location -
Former Monckton Coke and Colliery Works, Lund Hill Lane, Royston,
Barnsley, South Yorkshire, S71 4BD.

Geo2 Remediation Limited, The Coniston, Louisa Street, Idle, West Yorkshire, BD10 8NE

Tel: (0113) 2575397

www.geo2.co.uk

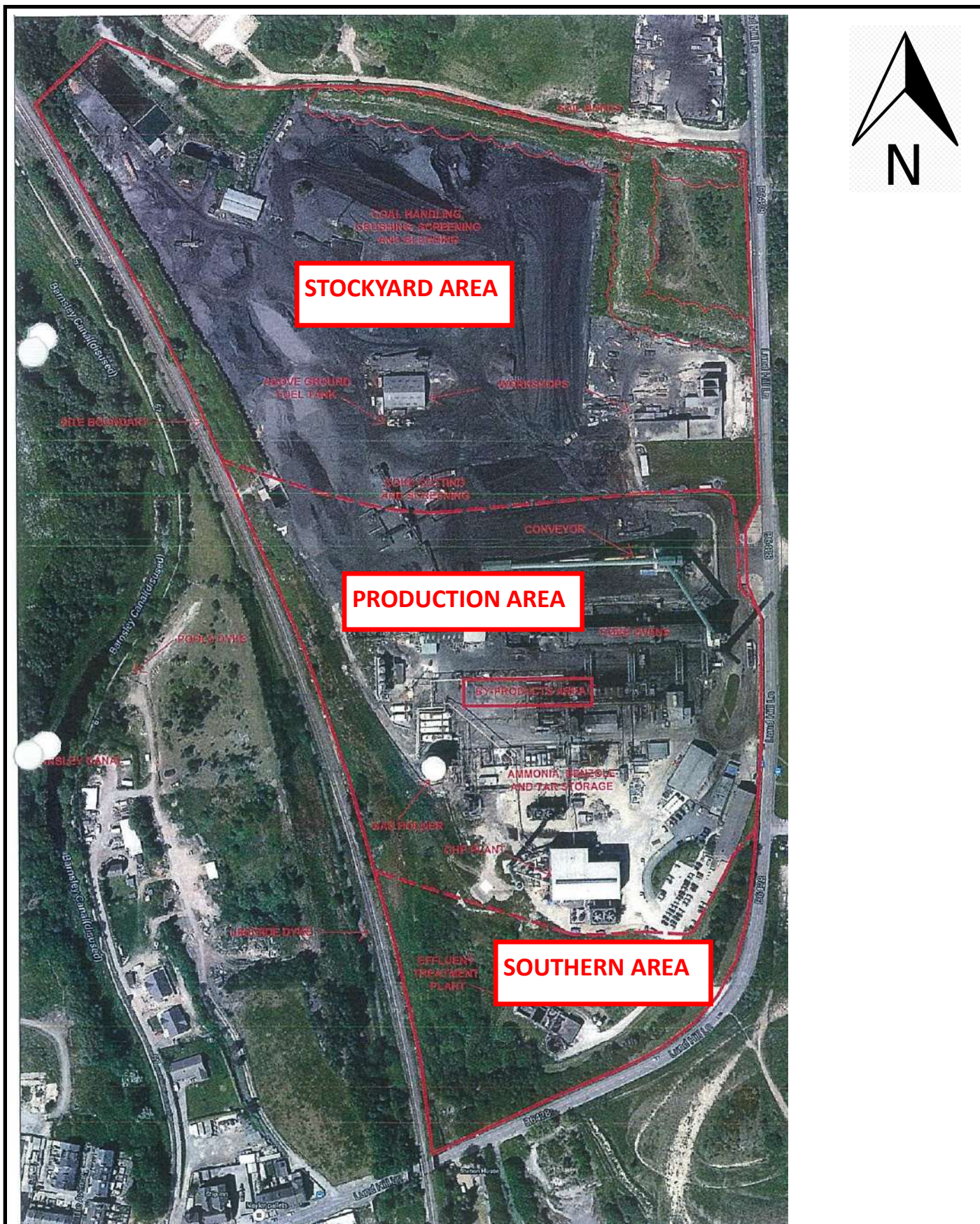


Figure 2— Aerial Photo and Site Layout

Drawn from Patrick Parsons 2015

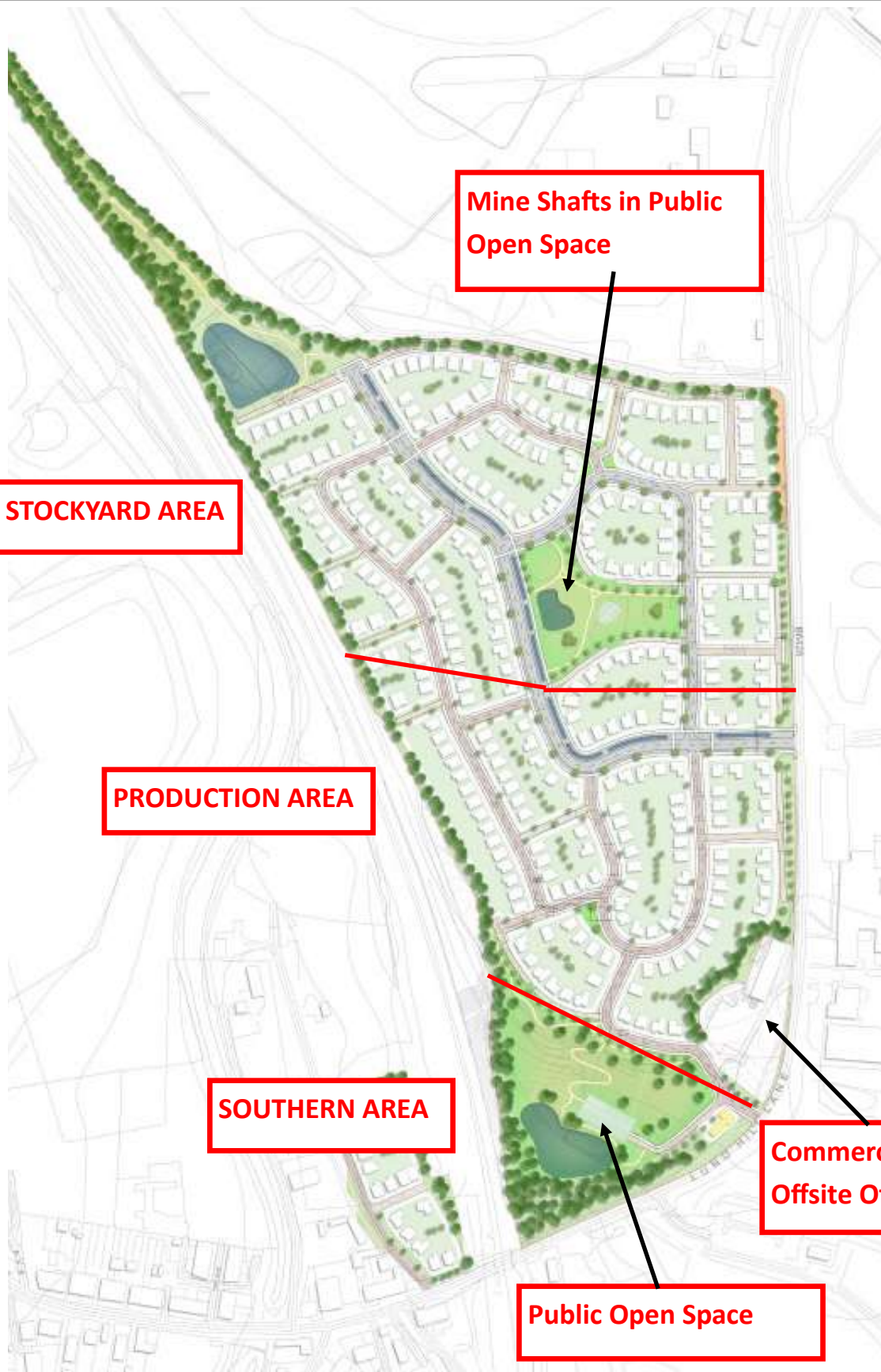
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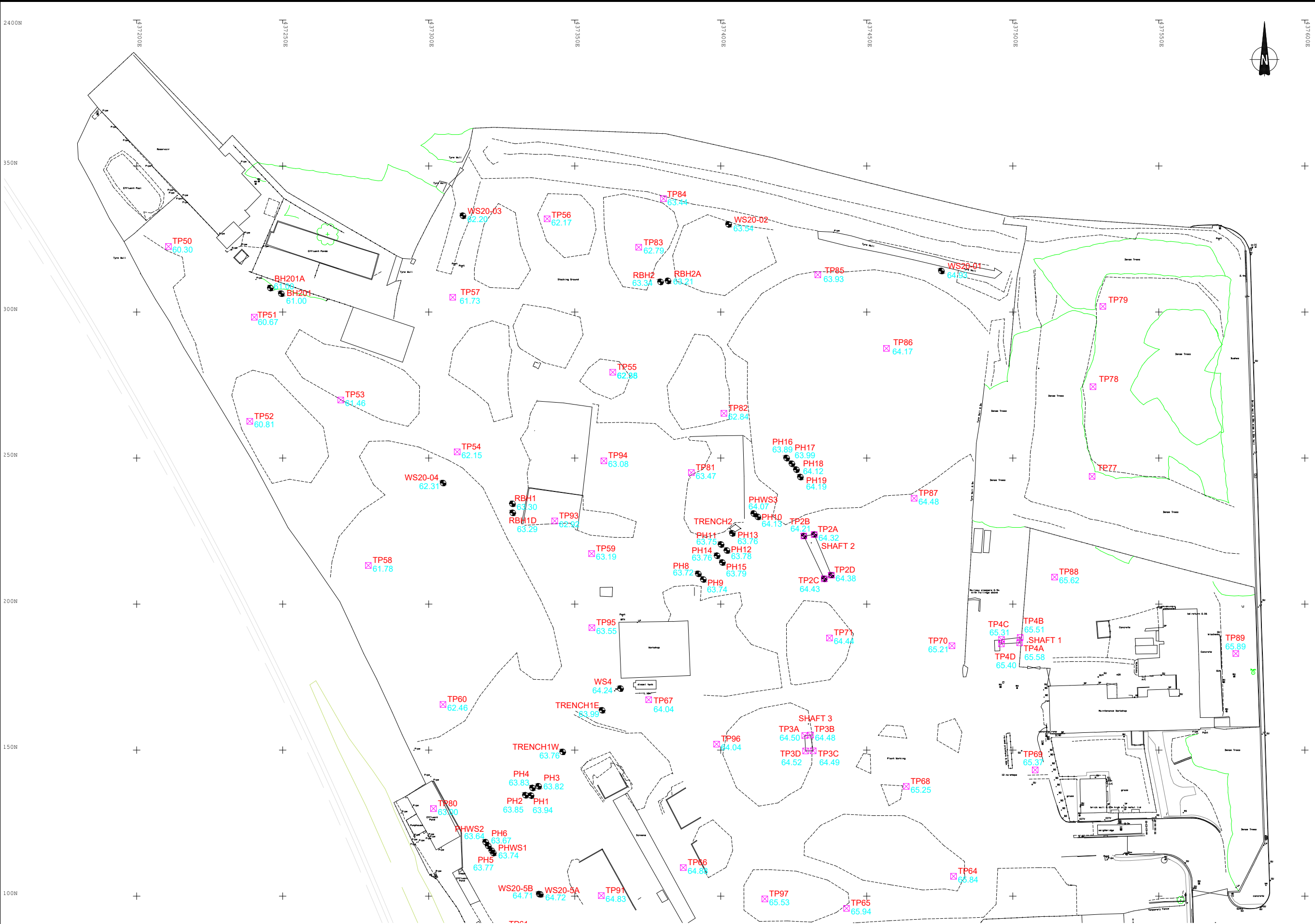
Figure 3 — Proposed Site Development Masterplan

Provided by Pegasus Group

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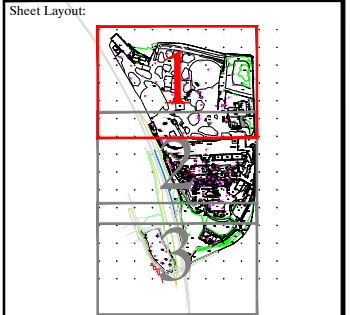


LEGEND

 Exploration Hole

 Trial Pit

Figure 4a
Site Investigation
Plan

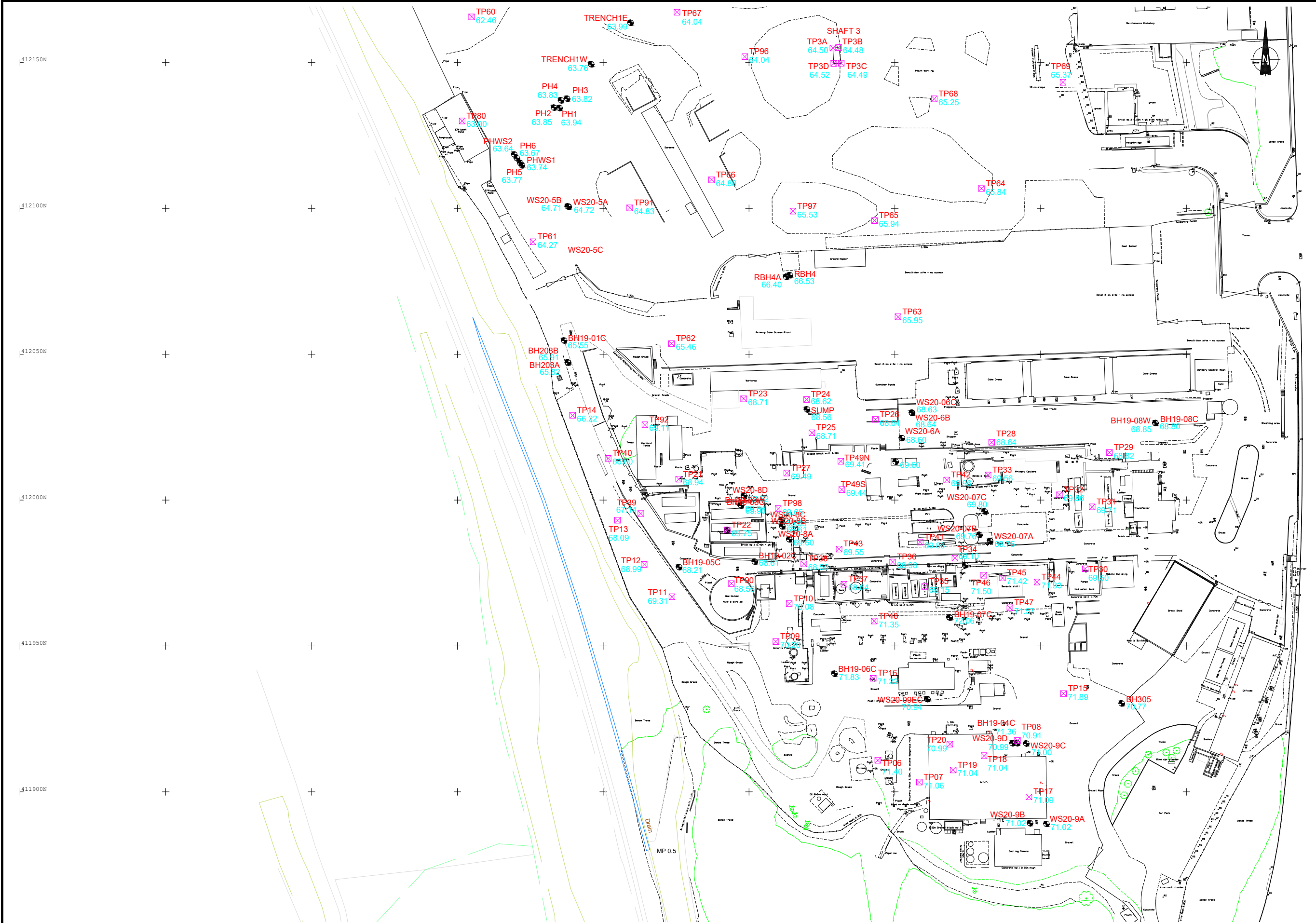


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Client: -

Site Location:
Monkton Coke Site

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Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 1 of 3



LEGEND

- Exploration Hole
- Trial Pit

Figure 4b
Site Investigation
Plan

Sheet Layout:



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-	-	15-07-20
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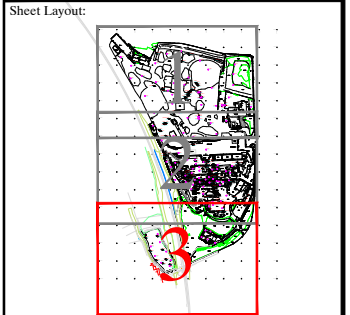


LEGEND

 Exploration Hole

 Trial Pit

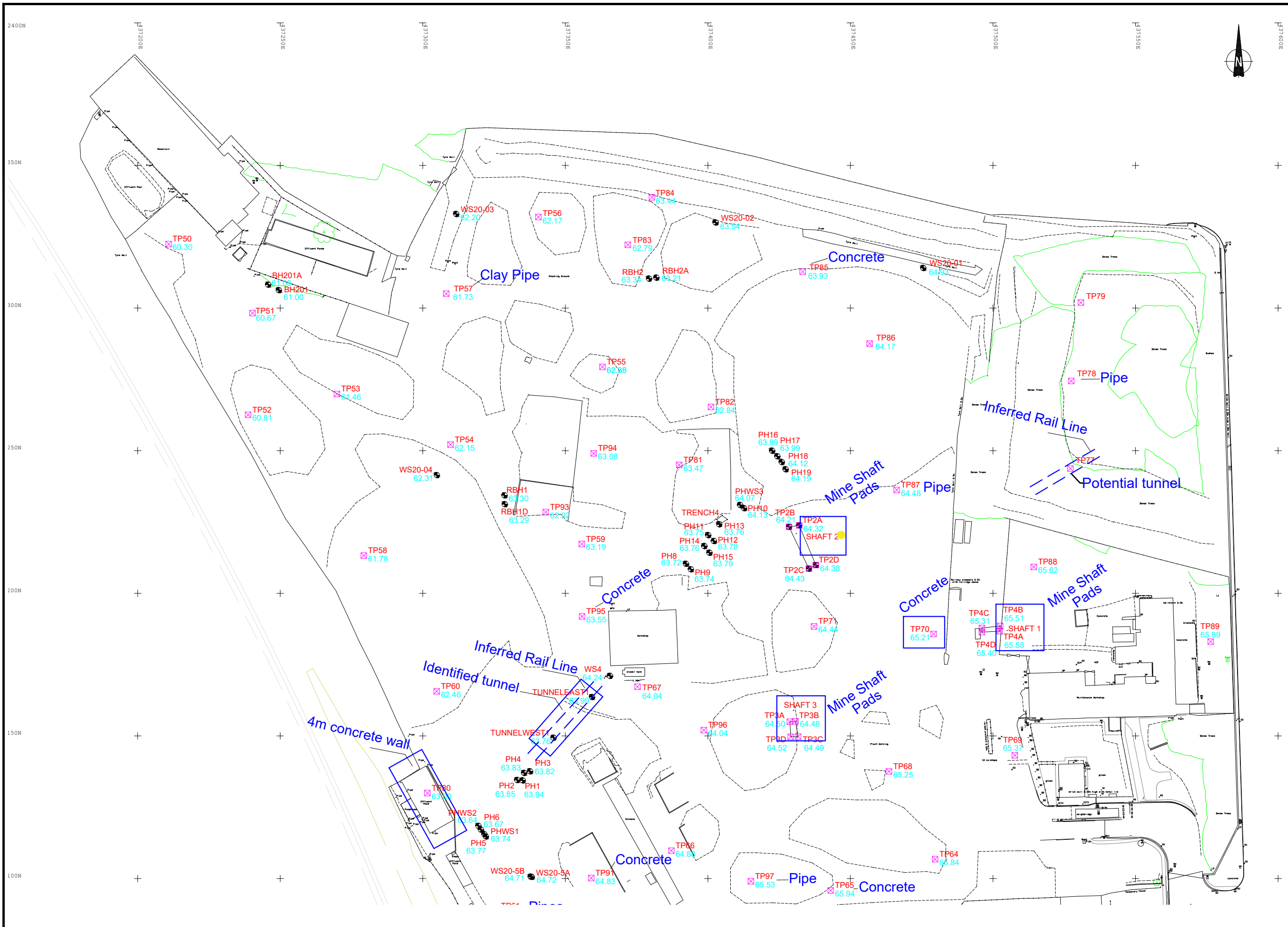
Figure 4c
Site Investigation
Plan



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1:1250@ A3	15-07-20	3 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

Figure 5a Obstruction Plan

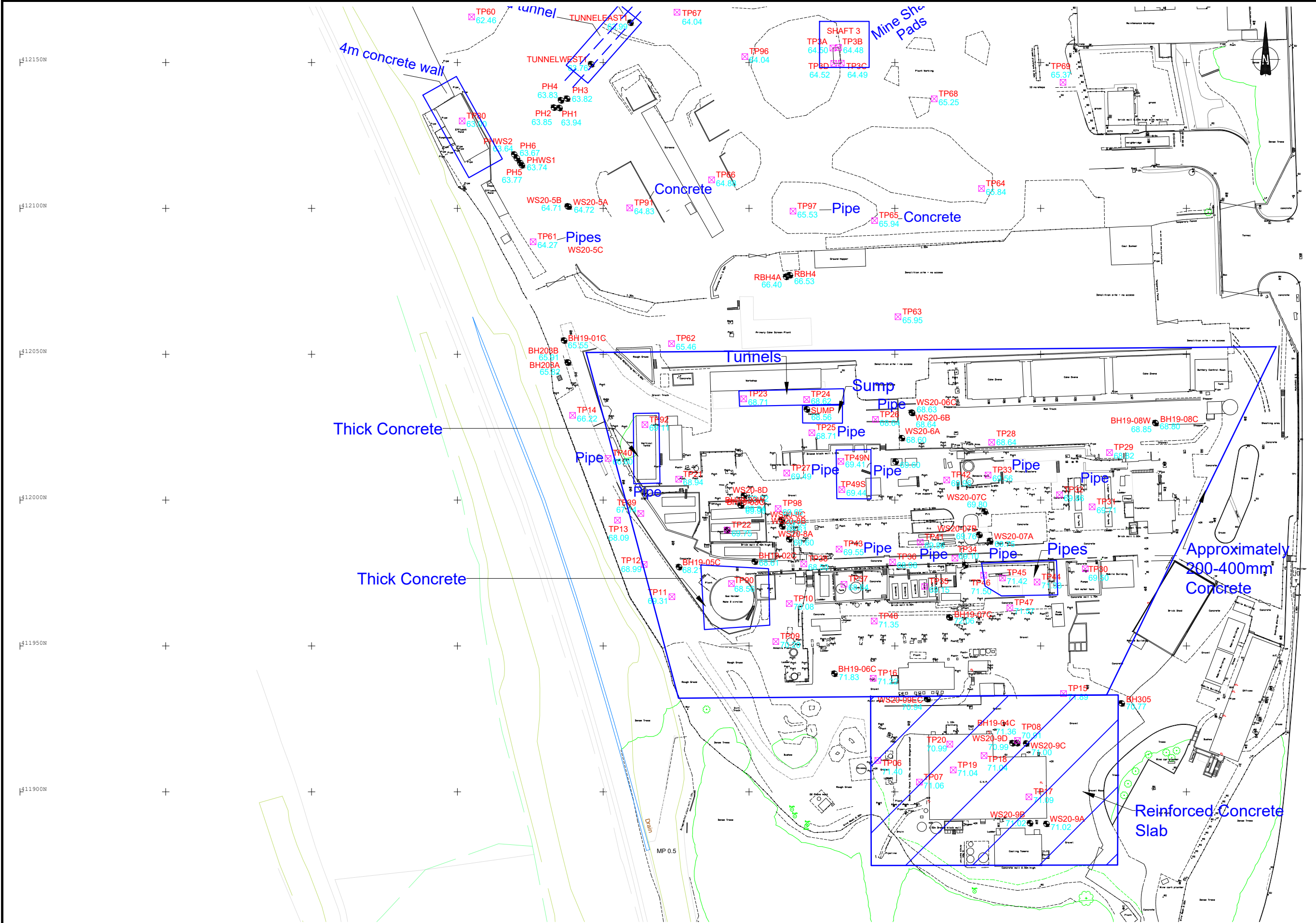
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LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

Figure 5b
Obstruction Plan

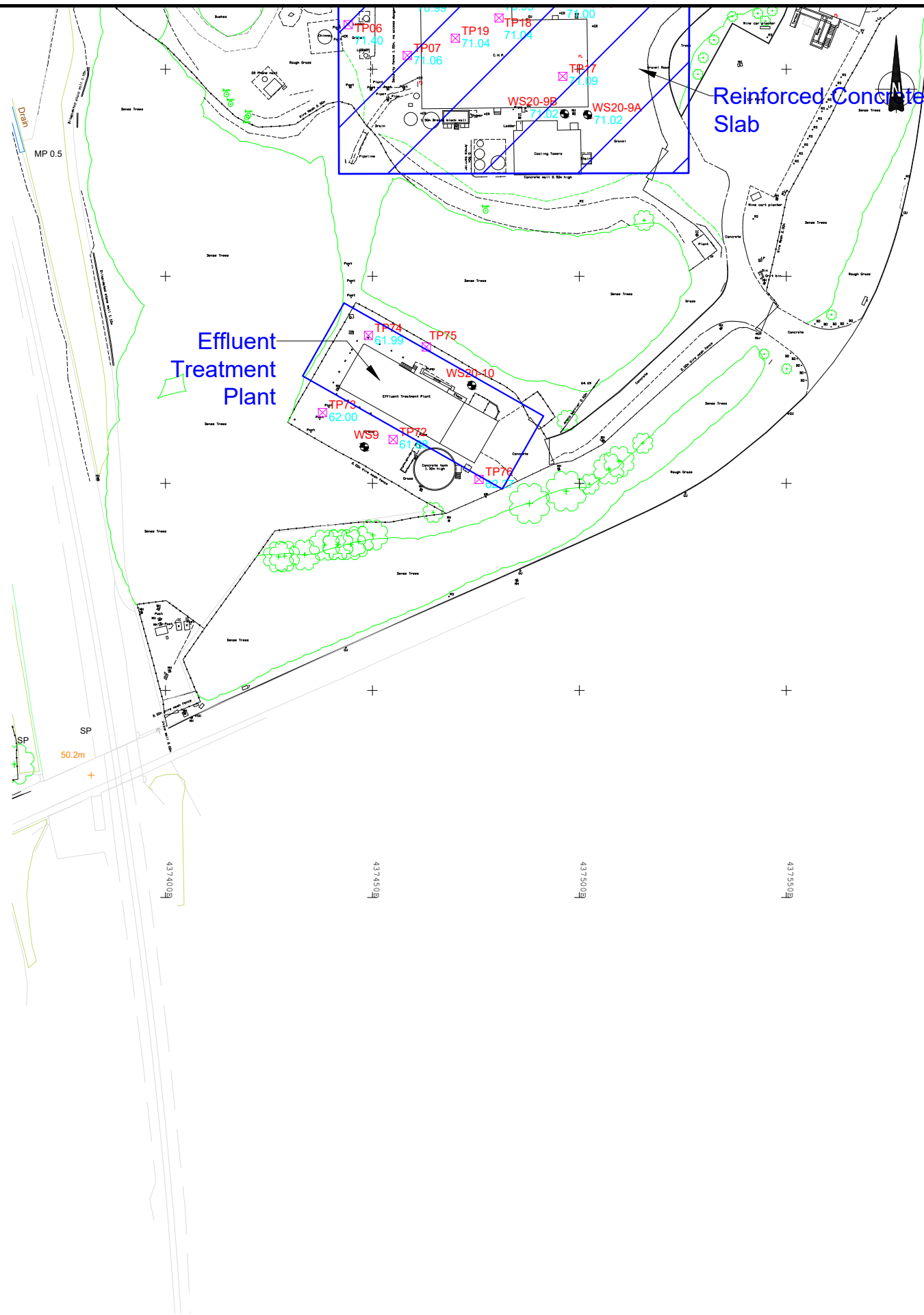
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Site Location:
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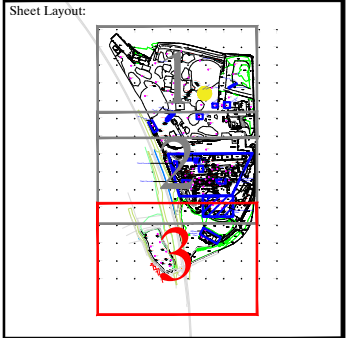
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LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

Figure 5c
Obstruction Plan



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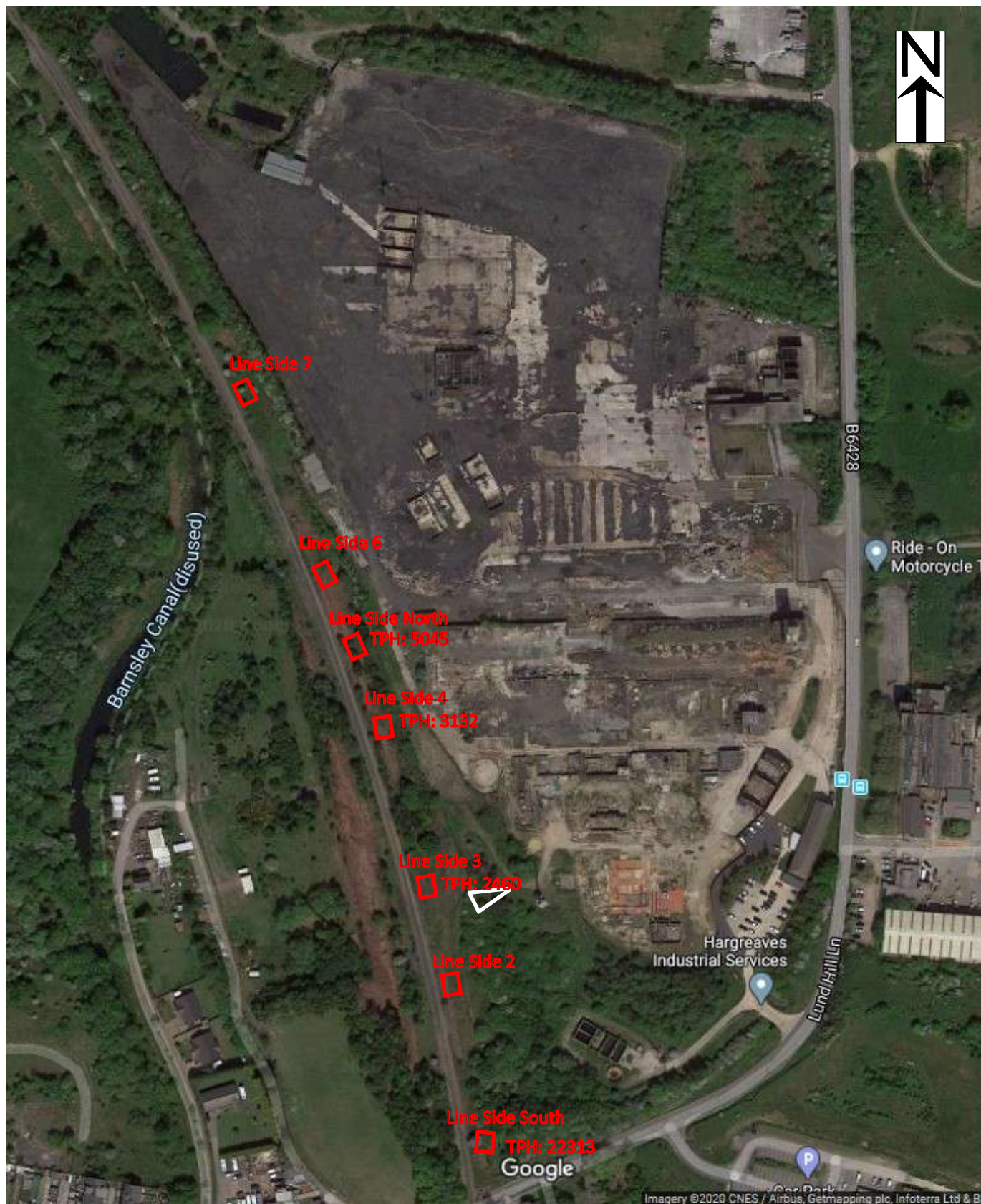


**Figure 7. Lineside Dyke Transect
Annotated with average TPH concentrations**

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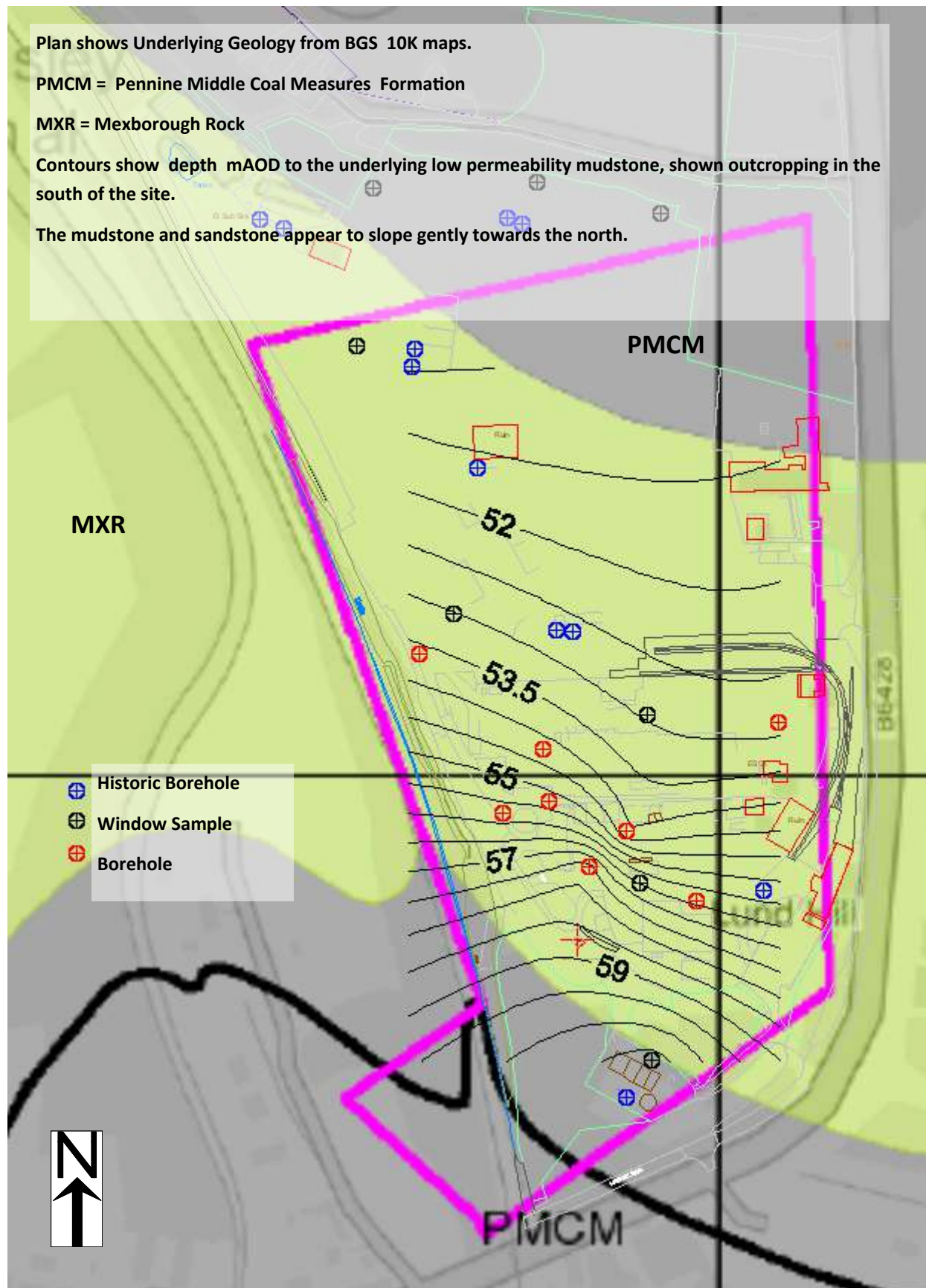
Plan shows Underlying Geology from BGS 10K maps.

PMCM = Pennine Middle Coal Measures Formation

MXR = Mexborough Rock

Contours show depth mAOD to the underlying low permeability mudstone, shown outcropping in the south of the site.

The mudstone and sandstone appear to slope gently towards the north.



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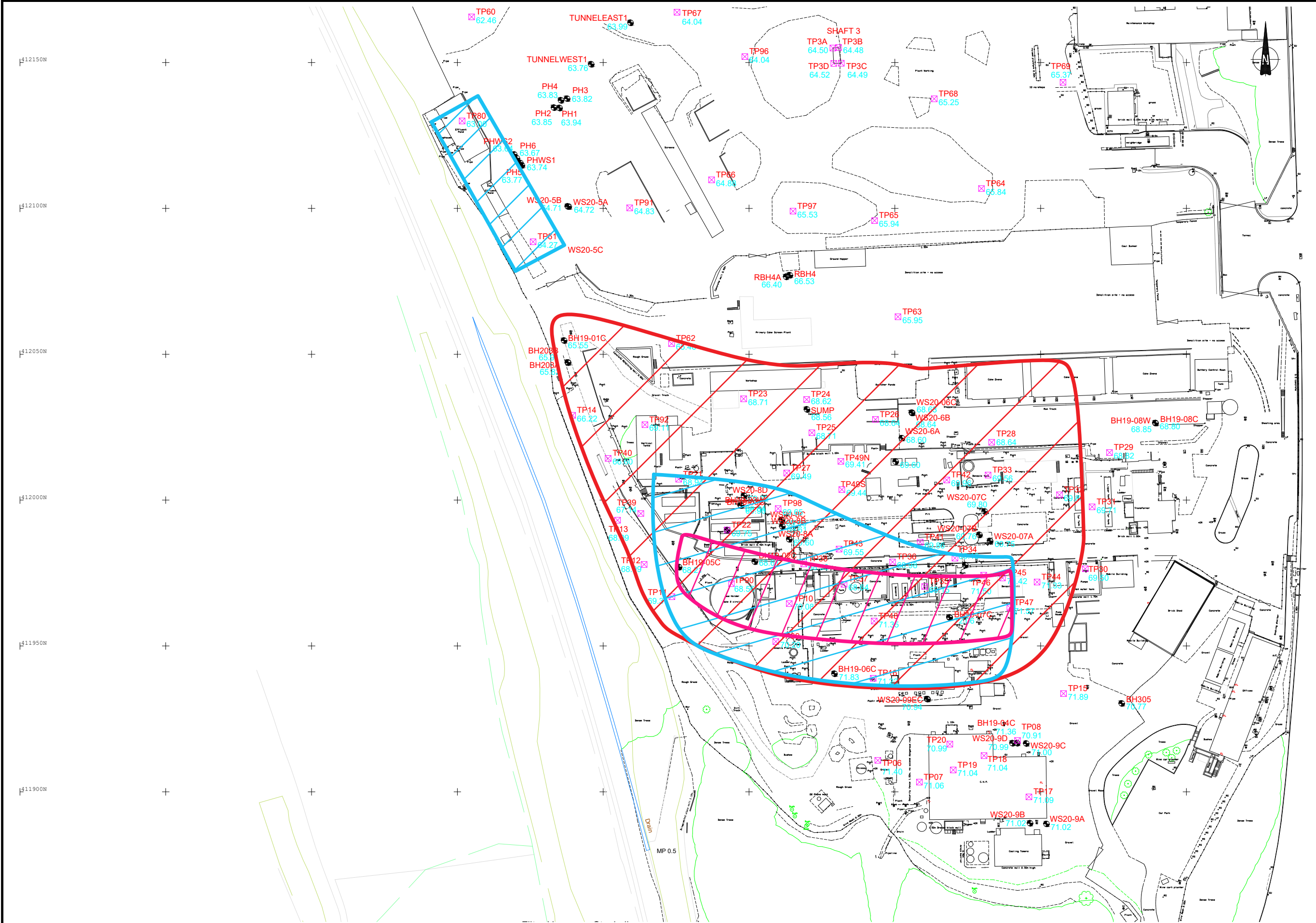


Figure 8 Plan showing geology, depth and slope of underlying mudstone

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LEGEND

- Exploration Hole
- Trial Pit
- Principal Source
- Secondary Source
- Tertiary Source

Figure 11
Key Areas
of Impact.

Sheet Layout:

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Monckton Coke Site

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LEGEND

- Exploration Hole
- Trial Pit
- Hydrocarbons
- Metals
- Inferred DNAPL
- Cyanide

Figure 10c
Significant
Groundwater
Impact.

Sheet Layout:

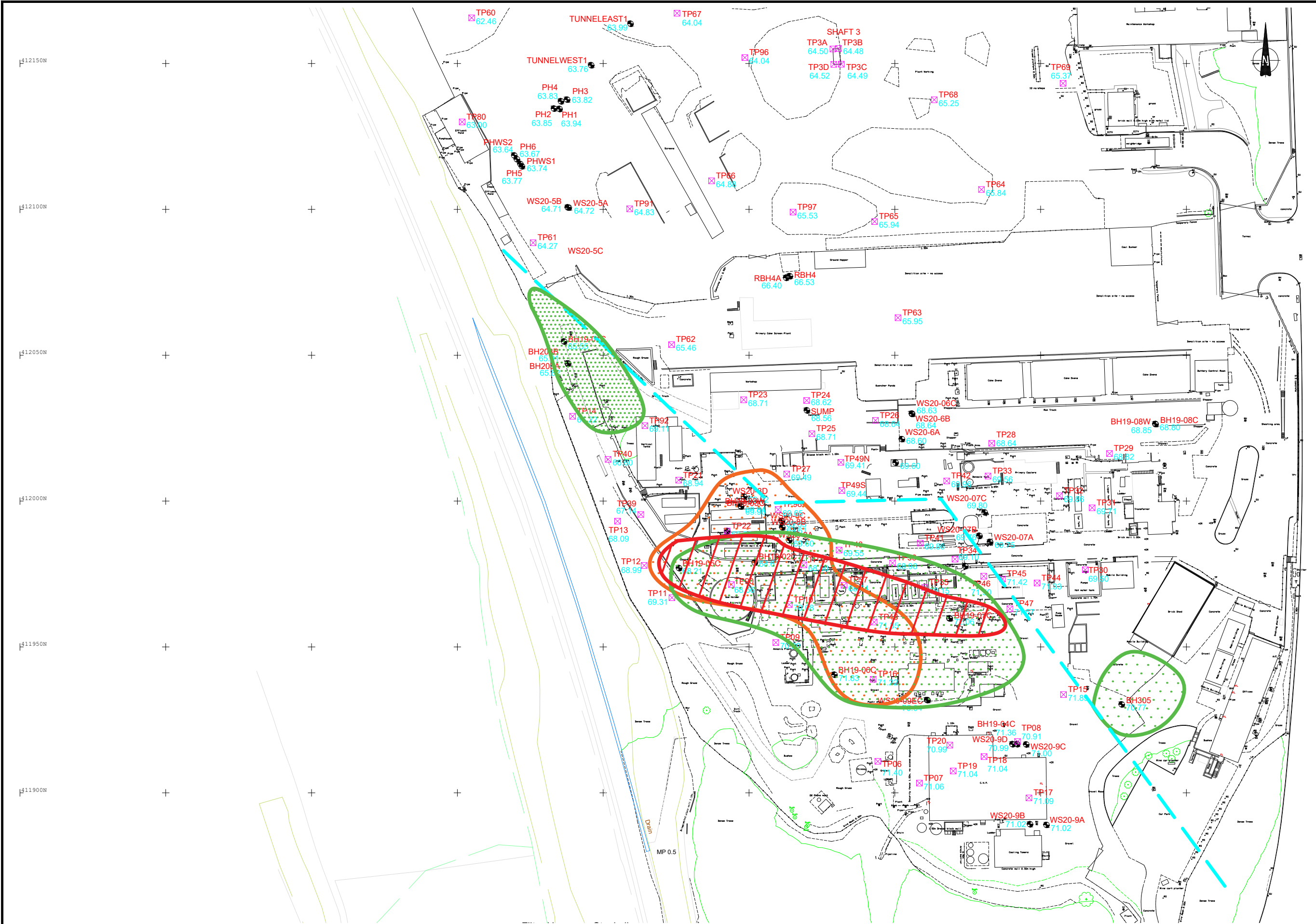
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LEGEND

- Exploration Hole
- Trial Pit
- Hydrocarbons
- Metals
- Inferred DNAPL
- Cyanide

Figure 10b
Significant
Groundwater
Impact.

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Monckton Coke Site

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	A.B.	
Drawing No.	0720-GEO2-7955	Revision
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 2 of 3

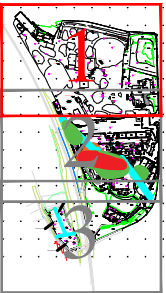


LEGEND

- Exploration Hole
- Trial Pit
- Hydrocarbons
- Metals
- Inferred DNAPL
- Cyanide

Figure 10a
Significant
Groundwater
Impact.

Sheet Layout:



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Site Location
Monckton Coke Site

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Scale 1:1250@ A3	Date 15-07-20	Sheet No. 1 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Hydrocarbons/PAH/Phenol
- Metals
- Cyanide
- Asbestos Containing Material

Figure 9c
Significant
Soil Impact

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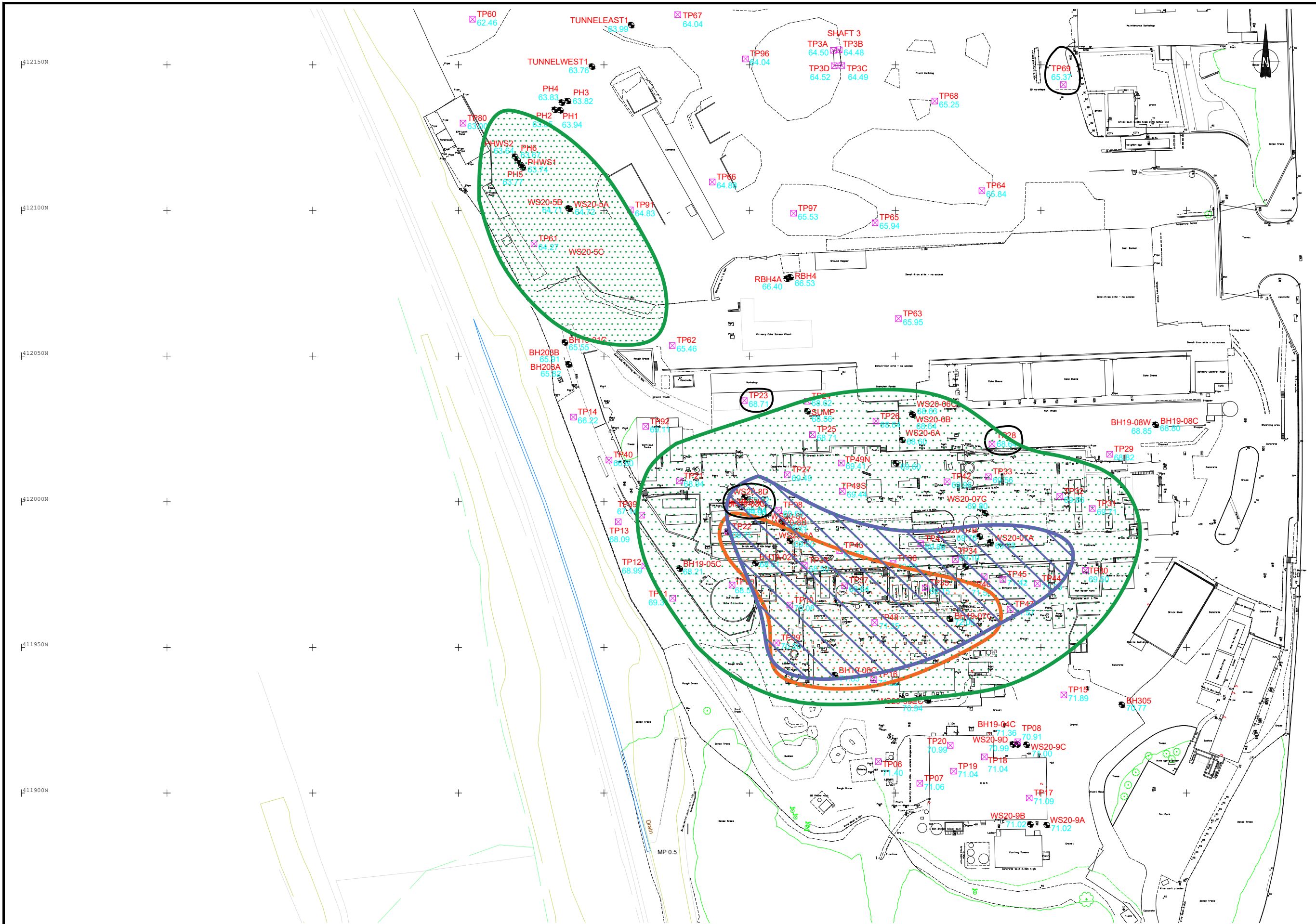
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Site Location: **Monckton Coke Site**

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Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 3 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Hydrocarbons/PAH/Phenol
- Metals
- Cyanide
- Asbestos Containing Material

Figure 9b
Significant
Soil Impact

Sheet Layout:

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Site Location

Monckton Coke Site

—

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Appendix B

Collated Laboratory Analysis

Project Name:	Monckton
Project Number:	1015
Area	Stockyard Area
Matrix	Groundwater

	Exceeds GAC
	Exceeds Relevant SSAC
	Poss DNAPL

Lab Sample ID	Units	Limit of Detection	Method	20/04754/1	20/04754/2	20/04754/3	20/04754/4									RTM
Client Sample No																
Client Sample ID				BH201	WS20-03	RBH1D	RBH2	Number of Samples	Min	Max	No. >detectio n	GAC	Source	No Exceeding GAC	Northern Plume	
Depth to Top																
Depth to Bottom																
Date Sampled				10-Jun-20	10-Jun-20	10-Jun-20	10-Jun-20									
Sample Type				Water - EW	Water - EW	Water - EW	Water - EW									
Sample Matrix Code				N/A	N/A	N/A	N/A									
Hardness Total	mg/l Ca CO3	2	A-T-049w	507		798	845	3	507	845	-					
Ammoniacal nitrogen as N (w)	mg/l	0.02	A-T-033w	<50.00		13.2	15.3	3	<50	15.3	2					
Cyanide (free) (w)	mg/l	0.005	A-T-042wFCN	<0.005		<0.005		2	<0.005	<0.005	0					
Cyanide (total) (w)	mg/l	0.005	A-T-042wTCN	0.07		0.018		2	0.018	0.07	2	0.05	Surf Wate	1	10.6	
Thiocyanate (w)	mg/l	0.1	A-T-041w	0.3		1		2	0.3	1	2	0.05	Surf Wate	2	10.6	
Phenols - Total by HPLC (w)	mg/l	0.01	A-T-050w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0	0.0077	EQS	0	447000000	
Arsenic (dissolved)	µg/l	1	A-T-025w	<1			1	2	<1	1	1	50	EQS	0	204	
Boron (dissolved)	µg/l	10	A-T-025w	200			119	2	119	200	2	1000	EQS	0		
Cadmium (dissolved)	µg/l	0.2	A-T-025w	<0.2			<0.2	2	<0.2	<0.2	0	5	EQS	0		
Copper (dissolved)	µg/l	1	A-T-025w	<1			1	2	<1	1	1	20	EQS	0		
Chromium (dissolved)	µg/l	1	A-T-025w	<1			<1	2	<1	<1	0	50	EQS	0		
Lead (dissolved)	µg/l	1	A-T-025w	<1			7	2	<1	7	1	0.05	EQS	1	No Impact	
Mercury (dissolved)	µg/l	0.1	A-T-025w	<0.1			<0.1	2	<0.1	<0.1	0	1	EQS	0		
Nickel (dissolved)	µg/l	1	A-T-025w	3			11	2	3	11	2	50	EQS	0	979000	
Selenium (dissolved)	µg/l	1	A-T-025w	<1			<1	2	<1	<1	0	10	DWS	0	1200	
Zinc (dissolved)	µg/l	1	A-T-025w	5			8	2	5	8	2	500	EQS	0		
PAH 16MS (w)																
Acenaphthene (w)	µg/l	0.01	A-T-019w	3.39		7.32	<0.01	3	<0.01	7.32	2					
Acenaphthylene (w)	µg/l	0.01	A-T-019w	0.12		0.22	0.02	3	0.02	0.22	3	0.1	EQS	2	1570	
Anthracene (w)	µg/l	0.01	A-T-019w	0.04		0.04	<0.01	3	<0.01	0.04	2					
Benzo(a)anthracene (w)	µg/l	0.01	A-T-019w	0.02		0.03	<0.01	3	<0.01	0.03	2					
Benzo(a)pyrene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0	0.00017	EQS	0	1.48	
Benzo(b)fluoranthene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0					
Benzo(ghi)perylene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0					
Benzo(k)fluoranthene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0					
Chrysene (w)	µg/l	0.01	A-T-019w	0.03		0.03	<0.01	3	<0.01	0.03	2					
Dibenzo(ah)anthracene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0					
Fluoranthene (w)	µg/l	0.01	A-T-019w	0.16		0.2	0.02	3	0.02	0.2	3	0.0063	EQS	3	776	
Fluorene (w)	µg/l	0.01	A-T-019w	0.2		1.08	<0.01	3	<0.01	1.08	2					
Indeno(123-cd)pyrene (w)	µg/l	0.01	A-T-019w	<0.01		<0.01	<0.01	3	<0.01	<0.01	0					
Napthalene (w)	µg/l	0.01	A-T-019w	0.07		0.08	<0.01	3	<0.01	0.08	2	2	EQS	0	755	
Phenanthrene (w)	µg/l	0.01	A-T-019w	0.24		0.2	0.02	3	0.02	0.24	3					
Pyrene (w)	µg/l	0.01	A-T-019w	0.14		0.17	0.02	3	0.02	0.17	3					
Total PAH 16MS (w)	µg/l	0.01	A-T-019w	4.41		9.37	0.08	3	0.02	9.37	3					
SVOC (w)																
1,2,4-Trichlorobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
1,2-Dichlorobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
1,3-Dichlorobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
1,4-Dichlorobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
2,4,5-Trichlorophenol	µg/l	1	A-T-052w					2	<1	<1	0					
2,4,6-Trichlorophenol	µg/l	1	A-T-052w					2	<1	<1	0					
2,4-Dichlorophenol	µg/l	1	A-T-052w					2	<1	<1	0					
2,4-Dimethylphenol	µg/l	1	A-T-052w					2	<1	<1	0					
2,4-Dinitrotoluene	µg/l	1	A-T-052w					2	<1	<1	0					
2,6-Dinitrotoluene	µg/l	1	A-T-052w					2	<1	<1	0					
2-Chloronaphthalene	µg/l	1	A-T-052w					2	<1	<1	0					
2-Chlorophenol	µg/l	1	A-T-052w					2	<1	<1	0					
2-Methylnaphthalene	µg/l	1	A-T-052w					2	<1	<1	0					
2-Methylphenol	µg/l	1	A-T-052w					2	<1	<1	0					
2-Nitrophenol	µg/l	1	A-T-052w					2	<1	<1	0					
4-Bromophenyl phenyl ether	µg/l	1	A-T-052w					2	<1	<1	0					
4-Chloro-3-methylphenol	µg/l	1	A-T-052w					2	<1	<1	0					
Bis(2-chloroisopropyl)ether	µg/l	1	A-T-052w					2	<1	<1	0					
3+4-Methylphenol	µg/l	1	A-T-052w					2	<1	<1	0					
4-Nitrophenol	µg/l	1	A-T-052w					2	<10	<10	0					
Acenaphthene	µg/l	1	A-T-052w					2	<1	<1	0					
Acenaphthylene	µg/l	1	A-T-052w					2	<1	<1	0					
Anthracene	µg/l	1	A-T-052w					2	<1	<1	0					
Bis(2-chloroethyl)ether	µg/l	1	A-T-052w					2	<1	<1	0					
Bis(2-chloroethoxy)methane	µg/l	1	A-T-052w					2	<1	<1	0					
Bis(2-ethylhexyl)phthalate	µg/l	10	A-T-052w					2	<10	<10	0					
Benzo(a)anthracene	µg/l	1	A-T-052w					2	<1	<1	0					
Butylbenzyl phthalate	µg/l	1	A-T-052w					2	<1	<1	0					
Benzo(b)fluoranthene	µg/l	1	A-T-052w					2	<1	<1	0					
Benzo(k)fluoranthene	µg/l	1	A-T-052w					2	<1	<1	0					
Benzo(a)pyrene	µg/l	1	A-T-052w					2	<1	<1	0					
Benzo(ghi)perylene	µg/l	1	A-T-052w					2	<1	<1	0					
Carbazole	µg/l	1	A-T-052w					2	<1	<1	0					
Chrysene	µg/l	1	A-T-052w					2	<1	<1	0					
Dibenzofuran	µg/l	1	A-T-052w					2	<1	<1	0					
n-Dibutylphthalate	µg/l	1	A-T-052w					2	<1	<1	0					
n-Dioctylphthalate	µg/l	10	A-T-052w					2	<10	<10	0					
n-Nitroso-n-dipropylamine	µg/l	1	A-T-052w					2	<1	<1	0					
Diethyl phthalate	µg/l	1	A-T-052w					2	<1	<1	0					
Dimethyl phthalate	µg/l	1	A-T-052w					2	<1	<1	0					
Dibenzo(ah)anthracene	µg/l	1	A-T-052w					2	<1	<1	0					
Fluorene	µg/l	1	A-T-052w					2	<1	<1	0					
Fluoranthene	µg/l	1	A-T-052w					2	<1	<1	0					
Hexachlorobutadiene	µg/l	1	A-T-052w					2	<1	<1	0					
Hexachlorobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
Pentachlorophenol	µg/l	1	A-T-052w					2	<1	<1	0					
Phenol	µg/l	1	A-T-052w					2	<1	<1	0					
Hexachloroethane	µg/l	1	A-T-052w					2	<1	<1	0					
Nitrobenzene	µg/l	1	A-T-052w					2	<1	<1	0					
Naphthalene	µg/l	1	A-T-052w					2	<1	<1	0					
Isophorone	µg/l	1	A-T-052w					2	<1	<1	0					
Hexachlorocyclopentadiene	µg/l	1	A-T-052w					2	<1	<1	0					
Phenanthrene	µg/l	1	A-T-052w					2	<1	<1	0					
Pyrene	µg/l	1	A-T-052w					2	<1	<1	0					
Indeno(1,2,3-cd)pyrene	µg/l	1	A-T-052w					2	<1	<1	0					
Perylene	µg/l	1	A-T-052w					2	<1	<1	0					
TPH CWG (w)																
Ali >C5-C6 (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	4	<1	<1	0					
Ali >C6-C8 (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	4	<1	<1	0	15000	WHO	0		
Ali >C8-C10 (w)	µg/l	5	A-T-055w	<5	<5	<5	<5	4	<5	<5	0	300	WHO	0		
Ali >C10-C12 (w)	µg/l	5	A-T-055w	<5	<5	<5	<5	4	<5	<5	0	300	WHO	0	3710	
Ali >C12-C16 (w)	µg/l	5	A-T-055w	<5	<5	<5	<5	4	<5	<5	0	300	WHO	0	No Impact	
Ali >C16-C21 (w)	µg/l	5	A-T-055w	<5	<5	<5	<5	4	<5	<5	0	NA				
Ali >C21-C35 (w)	µg/l	5	A-T-0													

MTBE (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	4	<1	<1	0				
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[illegible]

Project Name:	Monckton
Project Number:	1015
Area	South Area
Matrix	Groundwater

Exceeds GAC
Exceeds Relevant SSAC
Exceeds Leaching SSAC

Lab Sample ID	Units	Limit of Detection	Method	20/04754/8	20/04754/9	Number of Samples	Min	Max	No. >detection	GAC	Source	No Exceeding GAC	RTM
Client Sample No													Lineside Dyke
Client Sample ID				WS9	WS20-10								
Depth to Top													
Depth to Bottom													
Date Sampled				10-Jun-20	10-Jun-20								
Sample Type				Water - EW	Water - EW								
Sample Matrix Code				N/A	N/A								
Hardness Total	mg/l Ca CO3	2	A-T-049w	551	935	2	551	935	2				
Ammoniacal nitrogen as N (w)	mg/l	0.02	A-T-033w	0.46	0.31	2	0.31	0.46	2				
Cyanide (free) (w)	mg/l	0.005	A-T-042wFCN	0.022	0.008	2	0.008	0.022	2				
Cyanide (total) (w)	mg/l	0.005	A-T-042wTCN	0.896	0.376	2	0.376	0.896	2	0.05	Surf Wate	2	0.21
Thiocyanate (w)	mg/l	0.1	A-T-041w	0.9	1.3	2	0.9	1.3	2	0.05	Surf Wate	2	0.21
Phenols - Total by HPLC (w)	mg/l	0.01	A-T-050w	<0.01	<0.01	2	<0.01	<0.01	0	0.0077	EQS	0	0.33
Arsenic (dissolved)	µg/l	1	A-T-025w	<1	<1	2	<1	<1	0	50	EQS	0	204
Boron (dissolved)	µg/l	10	A-T-025w	233	95	2	95	233	2	1000	EQS	0	
Cadmium (dissolved)	µg/l	0.2	A-T-025w	<0.2	0.3	2	<0.2	0.3	1	5	EQS	0	
Copper (dissolved)	µg/l	1	A-T-025w	7	4	2	4	7	2	20	EQS	0	
Chromium (dissolved)	µg/l	1	A-T-025w	<1	4	2	<1	4	1	50	EQS	0	
Lead (dissolved)	µg/l	1	A-T-025w	<1	<1	2	<1	<1	0	0.05	EQS	1	3400000
Mercury (dissolved)	µg/l	0.1	A-T-025w	<0.1	<0.1	2	<0.1	<0.1	0	1	EQS	0	
Nickel (dissolved)	µg/l	1	A-T-025w	4	15	2	4	15	2	50	EQS	0	204
Selenium (dissolved)	µg/l	1	A-T-025w	14	22	2	14	22	2	10	DWS	2	40
Zinc (dissolved)	µg/l	1	A-T-025w	5	36	2	5	36	2	500	EQS	0	
PAH 16MS (w)													
Acenaphthene (w)	µg/l	0.01	A-T-019w	0.02	0.04	2	0.02	0.04	2				
Acenaphthylene (w)	µg/l	0.01	A-T-019w	<0.01	0.02	2	<0.01	0.02	1	0.1	EQS	0	584
Anthracene (w)	µg/l	0.01	A-T-019w	<0.01	0.03	2	<0.01	0.03	1				
Benzo(a)anthracene (w)	µg/l	0.01	A-T-019w	<0.01	0.06	2	<0.01	0.06	1				
Benzo(a)pyrene (w)	µg/l	0.01	A-T-019w	<0.01	0.04	2	<0.01	0.04	1	0.00017	EQS	1	0.732
Benzo(b)fluoranthene (w)	µg/l	0.01	A-T-019w	<0.01	0.04	2	<0.01	0.04	1				
Benzo(ghi)perylene (w)	µg/l	0.01	A-T-019w	<0.01	0.01	2	<0.01	0.01	1				
Benzo(k)fluoranthene (w)	µg/l	0.01	A-T-019w	<0.01	0.02	2	<0.01	0.02	1				
Chrysene (w)	µg/l	0.01	A-T-019w	<0.01	0.06	2	<0.01	0.06	1				
Dibenzo(ah)anthracene (w)	µg/l	0.01	A-T-019w	<0.01	<0.01	2	<0.01	<0.1	0				
Fluoranthene (w)	µg/l	0.01	A-T-019w	0.01	0.19	2	0.01	0.19	2	0.0063	EQS	2	392
Fluorene (w)	µg/l	0.01	A-T-019w	<0.01	0.02	2	<0.01	0.02	1				
Indeno(123-cd)pyrene (w)	µg/l	0.01	A-T-019w	<0.01	0.02	2	<0.01	0.02	1				
Naphthalene (w)	µg/l	0.01	A-T-019w	<0.01	<0.01	2	<0.01	<0.01	0	2	EQS	0	457
Phenanthrene (w)	µg/l	0.01	A-T-019w	<0.01	0.1	2	<0.01	0.1	1				
Pyrene (w)	µg/l	0.01	A-T-019w	0.01	0.18	2	0.01	0.18	2				
Total PAH 16MS (w)	µg/l	0.01	A-T-019w	0.04	0.83	2	0.04	0.83	2				
SVOC (w)													
1,2,4-Trichlorobenzene	µg/l	1	A-T-052w										
1,2-Dichlorobenzene	µg/l	1	A-T-052w										
1,3-Dichlorobenzene	µg/l	1	A-T-052w										
1,4-Dichlorobenzene	µg/l	1	A-T-052w										
2,4,5-Trichlorophenol	µg/l	1	A-T-052w										
2,4,6-Trichlorophenol	µg/l	1	A-T-052w										
2,4-Dichlorophenol	µg/l	1	A-T-052w										
2,4-Dimethylphenol	µg/l	1	A-T-052w										
2,4-Dinitrotoluene	µg/l	1	A-T-052w										
2,6-Dinitrotoluene	µg/l	1	A-T-052w										
2-Chloronaphthalene	µg/l	1	A-T-052w										
2-Chlorophenol	µg/l	1	A-T-052w										
2-Methylnaphthalene	µg/l	1	A-T-052w										
2-Methylphenol	µg/l	1	A-T-052w										
2-Nitrophenol	µg/l	1	A-T-052w										
4-Bromophenyl phenyl ether	µg/l	1	A-T-052w										
4-Chloro-3-methylphenol	µg/l	1	A-T-052w										
Bis(2-chloroisopropyl)ether	µg/l	1	A-T-052w										
3+4-Methylphenol	µg/l	1	A-T-052w										
4-Nitrophenol	µg/l	1	A-T-052w										
Acenaphthene	µg/l	1	A-T-052w										
Acenaphthylene	µg/l	1	A-T-052w										
Anthracene	µg/l	1	A-T-052w										
Bis(2-chloroethyl)ether	µg/l	1	A-T-052w										
Bis(2-chloroethoxy)methane	µg/l	1	A-T-052w										
Bis(2-ethylhexyl)phthalate	µg/l	10	A-T-052w										
Benzo(a)anthracene	µg/l	1	A-T-052w										
Butylbenzyl phthalate	µg/l	1	A-T-052w										
Benzo(b)fluoranthene	µg/l	1	A-T-052w										
Benzo(k)fluoranthene	µg/l	1	A-T-052w										
Benzo(a)pyrene	µg/l	1	A-T-052w										
Benzo(ghi)perylene	µg/l	1	A-T-052w										
Carbazole	µg/l	1	A-T-052w										
Chrysene	µg/l	1	A-T-052w										
Dibenzofuran	µg/l	1	A-T-052w										
n-Dibutylphthalate	µg/l	1	A-T-052w										
n-Dioctylphthalate	µg/l	10	A-T-052w										
n-Nitroso-n-dipropylamine	µg/l	1	A-T-052w										
Diethyl phthalate	µg/l	1	A-T-052w										
Dimethyl phthalate	µg/l	1	A-T-052w										
Dibenzo(ah)anthracene	µg/l	1	A-T-052w										
Fluorene	µg/l	1	A-T-052w										
Fluoranthene	µg/l	1	A-T-052w										
Hexachlorobutadiene	µg/l	1	A-T-052w										
Hexachlorobenzene	µg/l	1	A-T-052w										
Pentachlorophenol	µg/l	1	A-T-052w										
Phenol	µg/l	1	A-T-052w										
Hexachloroethane	µg/l	1	A-T-052w										
Nitrobenzene	µg/l	1	A-T-052w										
Naphthalene	µg/l	1	A-T-052w										
Isophorone	µg/l	1	A-T-052w										
Hexachlorocyclopentadiene	µg/l	1	A-T-052w										
Phenanthrene	µg/l	1	A-T-052w										
Pyrene	µg/l	1	A-T-052w										
Indeno(1,2,3-cd)pyrene	µg/l	1	A-T-052w										
Perylene	µg/l	1	A-T-052w										
TPH CWG (w)													
Ali >C5-C6 (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0					
Ali >C6-C8 (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0		15000	WHO	0	
Ali >C8-C10 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		300	WHO	0	
Ali >C10-C12 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		300	WHO	0	257
Ali >C12-C16 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		300	WHO	0	No Impact
Ali >C16-C21 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		NA			
Ali >C21-C35 (w)	µg/l	5	A-T-055w	<5	5	2	<5	5	1	NA			
Total Aliphatics (w)	µg/l	5	A-T-055w	<5	5	2	<5	5	1				
Aro >C5-C7 (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0		1	WHO	0	No Impact
Aro >C7-C8 (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0		70	WHO	0	1770
Aro >C8-C10 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		300	WHO	0	2390
Aro >C10-C12 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		90	WHO	0	459
Aro >C12-C16 (w)	µg/l	5	A-T-055w	<5	<5	2	<5	0		90	WHO	0	584
Aro >C16-C21 (w)	µg/l	5	A-T-055w	<5	7	2	<5	7	1	90	WHO	0	423
Aro >C21-C35 (w)	µg/l	10	A-T-055w	<10	<10	2	<10	0		90	WHO	0	392
Total Aromatics (w)	µg/l	10	A-T-055w	<10	<10	2	<10	0					
TPH (Ali & Aro >C5-C35) (w)	µg/l	10	A-T-055w	<10	12	2	<10	12	1				
BTEX - Benzene (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0		10	EQS	0	No Impact
BTEX - Toluene (w)	µg/l	1	A-T-022w	<1	<1	2	<1	0		74	EQS	0	1770
BTEX - Ethyl Benzene (w)	µg/l	1	A-T-022w	<1	<1	2	<5	0		300	DWS	0	
BTEX - m & p Xylene (w)	µg/l	1	A-T-022w	<1	<1	2	<5	0		500	DWS	0	2390
BTEX - o Xylene (w)	µg/l	1	A-T-022w	<1	<1	2	<5	0		500	DWS	0	2390
MTBE (w)	µg/l	1	A-T-022w	<1	<1	2	<5	0					

Project Name:	Monckton
Project Number:	1015
Area	South Area
Matrix	Soil

	Exceeds GAC
	Exceeds Relevant SSAC
	Exceeds Leaching SSAC

Lab Sample ID	Units	Limit of Detection	Method	20/04677/5	20/04677/1	20/04677/6	20/04677/4	20/04677/3	20/04677/2	20/03816/5	20/03816/6	20/03816/7	Number of Samples	Min	Max	No. >detection	RESI (WITH PLANT) UPTAKE	CLEA		
Client Sample No				HH Exposure		HH Exposure	RTM Leaching to Controlled Waters													
Client Sample ID																				
Depth to Top																				
Depth to Bottom																				
Date Sampled	Sample Type	Sample Matrix Code	10-Jun-20	10-Jun-20	10-Jun-20	10-Jun-20	10-Jun-20	10-Jun-20	05-May-20	05-May-20	05-May-20	No. > GAC Value	Lineside Dyke							
Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil									
5ABE	6AE	5A	5AE	6AE	5A	4ABE	3A	4AB												
% Stones >10mm	% w/w	0.1	A-T-044	1.6	<0.1	5.4	<0.1	32.7	<0.1	13.5	<0.1	20.8	6	5.59	8.39					
pH	pH	0.01	A-T-031s		8.23	7.77	6.27	8.39	5.59	7.27										
Moisture																				
Calorific Value																				
Sulphate (water sol 2:1)						0.1		0.05					2	0.05	0.1	2				
Sulphate (acid soluble)	mg/kg	200	A-T-028s							430			1	430	430	1				
Sulphur (total)	mg/kg	50	A-T-024s			275		289		179			3	179	289	3				
Cyanide (free)	mg/kg	1	A-T-042sFCN			1	<1		<1				3	<1	1	1				
Cyanide (total)	mg/kg	1	A-T-042sTCN			42	<1		<1				3	<1	42	1				102
Thiocyanate	mg/kg	5	A-T-041s			<5	<5		<5				3	<5	0	0				102
Total Organic Carbon	% w/w	0.03	A-T-032s		2.76				0.27	0.91			3	0.27	2.76					
Arsenic	mg/kg	1	A-T-024s	8	16		<1	4				2	5	<1	16	4	37	0	37.1	701
Barium	mg/kg	1	A-T-024s	262	210		555	77					4	77	555	4	1300	0		
Beryllium	mg/kg	0.5	A-T-024s	1.2	1.3		1.6	0.5					4	0.5	1.6	4	1.7	0	72.6	
Cadmium	mg/kg	0.5	A-T-024s	0.6	0.5		0.7	<0.5				<0.5	5	<0.5	0.7	3	22	0		
Copper	mg/kg	1	A-T-024s	31	57		30	20					9	5	57	5	2400	0		
Chromium	mg/kg	1	A-T-024s	25	18		36	355					15	5	15	355	5	910	0	
Lead	mg/kg	1	A-T-024s	65	137		18	15					10	5	10	137	5	200	0	201
Mercury	mg/kg	0.17	A-T-024s	<0.17	0.22		<0.17	0.5					0.24	5	<0.17	0.5	3	1.2	0	No Impact
Nickel	mg/kg	1	A-T-024s	30	21		52	198					18	5	18	198	5	180	1	590
Selenium	mg/kg	1	A-T-024s	<1	<1		<1	1					<1	5	<1	1	1	250	0	167
Vanadium	mg/kg	1	A-T-024s	28	28		31	14					4	14	31	4	410	0	0.813	
Zinc	mg/kg	5	A-T-024s	101	104		90	34					33	5	33	104	5	3700	0	
Asbestos in Soil (inc. matrix)																				
Asbestos in soil			A-T-045																	
Asbestos Matrix (microscope)			A-T-045	NAD	Chrysotile		NAD	NAD					4	NAD	0	1				
Asbestos ACM - Suitable for Water Absorption Test			A-T-045	-	Loose Fibres		-	-												
				N/A	N/A		N/A	N/A												
Asbestos in Soil Quantification % (Hand Picking & Weighing)																				
Asbestos in soil % composition	% w/w	0.001	A-T-054		<0.001								1	<0.001	0	0				
Speciated PCB-WHO12																				
PCB BZ 81	mg/kg	0.005	A-T-004s																	
PCB BZ 105	mg/kg	0.005	A-T-004s																	
PCB BZ 114	mg/kg	0.005	A-T-004s																	
PCB BZ 118	mg/kg	0.007	A-T-004s																	
PCB BZ 123	mg/kg	0.005	A-T-004s																	
PCB BZ 126	mg/kg	0.005	A-T-004s																	
PCB BZ 156	mg/kg	0.005	A-T-004s																	
PCB BZ 157	mg/kg	0.005	A-T-004s																	
PCB BZ 167	mg/kg	0.005	A-T-004s																	
PCB BZ 169	mg/kg	0.005	A-T-004s																	
PCB BZ 189	mg/kg	0.005	A-T-004s																	
PCB BZ 77	mg/kg	0.005	A-T-004s																	
Total Speciated PCB-WHO12	mg/kg	0.005	A-T-004s																	
SVOC																				
Hexachlorobenzene	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
Diethyl phthalate	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
Dimethyl phthalate	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
Dibenzofuran	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0			NC	
Carbazole	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0			NA	
Butylbenzyl phthalate	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
Bis(2-ethylhexyl)phthalate	µg/kg	500	A-T-052s			955			<500				2	<500	955	1	2700	0		
Bis(2-chloroethoxy)methane	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
Bis(2-chloroethyl)ether	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
4-Nitrophenol	µg/kg	100	A-T-052s			<1000			<1000				2	<1000	0	0				
3+4-Methylphenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0			342000	
4-Chloro-3-methylphenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2-Nitrophenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2-Methylphenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0			342000	
2-Chlorophenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2,6-Dinitrotoluene	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2,4-Dinitrotoluene	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2,4-Dimethylphenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2,4-Dichlorophenol	µg/kg	100	A-T-052s			<100			<100				2	<100	0	0				
2,4,6-Trichlorophenol																				

m & p Xylene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0			161000	1490000
o-Xylene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0			174000	1490000
Styrene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
Bromoforn	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
Isopropylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,1,2,2-Tetrachloroethane	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,2,3-Trichloropropane	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
Bromobenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
n-Propylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
2-Chlorotoluene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,3,5-Trimethylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
4-Chlorotoluene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
tert-Butylbenzene	µg/kg	2	A-T-006s			<2			<2			2	<2	0	0				
1,2,4-Trimethylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0			6360	
sec-Butylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
4-Isopropyltoluene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,3-Dichlorobenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,4-Dichlorobenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
n-Butylbenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,2-Dichlorobenzene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,2-Dibromo-3-chloropropane (DCBP)	µg/kg	2	A-T-006s			<2			<2			2	<2	0	0				
1,2,4-Trichlorobenzene	µg/kg	3	A-T-006s			<3			<3			2	<3	0	0				
Hexachlorobutadiene	µg/kg	1	A-T-006s			<1			<1			2	<1	0	0				
1,2,3-Trichlorobenzene	µg/kg	3	A-T-006s			<3			<3			2	<3	0	0				
TPH CWG																			
Ali >C5-C6	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	7	<0.01	0	0	42	0		
Ali >C6-C8	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.01	7	<0.01	0	0	100	0		
Ali >C8-C10	mg/kg	1	A-T-055s	1	1	<1	<1	<1	<1		<1	7	<1	0	0	27	0	74.7	
Ali >C10-C12	mg/kg	1	A-T-055s	<1	<1	<1	<1	<1	<1		<1	7	<1	0	0	130	0	373	257
Ali >C12-C16	mg/kg	1	A-T-055s	1	2	<1	<1	<1	<1		<1	7	<1	2	2	1100	0		No Impact
Ali >C16-C21	mg/kg	1	A-T-055s	2	4	<1	<1	2	<1		<1	7	<1	4	3	65000	0		
Ali >C21-C35	mg/kg	1	A-T-055s	25	11	<1	<1	7	<1		<1	7	<1	25	3	65000	0		
Total Aliphatics	mg/kg	1	A-T-055s	30	18	<1	<1	10	<1		<1	7	<1	30	3				
Aro >C5-C7	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.04	7	<0.01	0.04	1	70	0	233	No Impact
Aro >C7-C8	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.02	7	<0.01	0.02	1	130	0	489	1730
Aro >C8-C10	mg/kg	1	A-T-055s	3	4	<1	<1	1	<1		<1	7	<1	4	2	34	0	110	2390
Aro >C10-C12	mg/kg	1	A-T-055s	2	2	<1	<1	<1	<1		<1	7	<1	2	2	74	0	290	459
Aro >C12-C16	mg/kg	1	A-T-055s	6	7	<1	<1	3	<1		<1	7	<1	7	2	140	0	545	584
Aro >C16-C21	mg/kg	1	A-T-055s	10	39	<1	<1	12	<1		<1	7	<1	39	3	260	0	809	423
Aro >C21-C35	mg/kg	1	A-T-055s	35	179	<1	2	54	<1		2	7	<1	179	5	1100	0	1660	392
Total Aromatics	mg/kg	1	A-T-055s	56	231	<1	2	72	<1		2	7	<1	231	5				
TPH (Ali & Aro >C5-C35)	mg/kg	1	A-T-055s	86	249	<1	2	83	<1		2	7	<1	249	5				
BTEX - Benzene	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.04	7	<0.01	0.04	1	0.087	0	0.42	No Impact
BTEX - Toluene	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		0.02	7	<0.01	0.02	1	47	0	489	1730
BTEX - Ethyl Benzene	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	7	<0.01	<0.01	0	130	0	268	
BTEX - m & p Xylene	mg/kg	0.01	A-T-022s	0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	7	<0.01	<0.01	1	59	0	161	2390
BTEX - o Xylene	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	7	<0.01	<0.01	0	60	0	174	2390
MTBE	mg/kg	0.01	A-T-022s	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	7	<0.01	<0.01	0				

Aro >C12-C16	mg/l	1	A-T-055s										350000																
Aro >C16-C21	mg/l	1	A-T-055s										104000																
Aro >C21-C35	mg/l	1	A-T-055s										63800																
Total Aromatics	mg/l	1	A-T-055s										1110000																
TPH (Ali & Aro >C5-C35)	mg/l	1	A-T-055s										1150000																
BTEX - Benzene	mg/l	0.01	A-T-022s										>1330																
BTEX - Toluene	mg/l	0.01	A-T-022s										>1030																
BTEX - Ethyl Benzene	mg/l	0.01	A-T-022s										>430																
BTEX - m & p Xylene	mg/l	0.01	A-T-022s										>851																
BTEX - o Xylene	mg/l	0.01	A-T-022s										>673																
MTBE	mg/l	0.01	A-T-022s										<2.50																
TPH CWG (w)																													
Ali >C5-C6 (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1				10	<1.0	0	0									
Ali >C6-C8 (w)	µg/l	1	A-T-022w	<1	<1	<1	2	17	<1	<1	11	9	<1				10	<1	17	4	15000	WHO	0						
Ali >C8-C10 (w)	µg/l	5	A-T-055w	<5	<5	<5	124	250	<5	20	214	137	<5				10	<5	250	6	300	WHO	0						
Ali >C10-C12 (w)	µg/l	5	A-T-055w	5	<5	<5	<25	164	<5	9	352	99	7				10	<5	352	6	300	WHO	1				3710	257	
Ali >C12-C16 (w)	µg/l	5	A-T-055w	<5	<5	<5	86	63	<5	<5	865	<25	<5				10	<5	865	3	300	WHO	1				No Impact	No Impact	
Ali >C16-C21 (w)	µg/l	5	A-T-055w	<5	<5	<5	264	<50	<5	<5	718	<25	<5				10	<5	718	8	NA								
Ali >C21-C35 (w)	µg/l	5	A-T-055w	6	<5	9	118	194	6	8	360	82	12				10	<5	360	9	NA								
Total Aliphatics (w)	µg/l	5	A-T-055w	11	<5	9	594	688	6	37	2520	326	18				10	<5	2520	9									
Aro >C5-C7 (w)	µg/l	1	A-T-022w	7	<1	<1	15	4203	2	174	2519	1075	20				10	<1	4203	8	1	WHO	8				No Impact	No Impact	
Aro >C7-C8 (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	1848	<1	1	707	336	3				10	<1	1848	5	70	WHO	3				37300	1770	
Aro >C8-C10 (w)	µg/l	5	A-T-055w	120	<5	6	3540	7100	<5	126	5830	3430	20				10	<5	7100	8	300	WHO	4				3450	2390	
Aro >C10-C12 (w)	µg/l	5	A-T-055w	787	<5	16	3800	42700	<5	73	47700	21700	49				10	<5	47700	8	90	WHO	5				755	459	
Aro >C12-C16 (w)	µg/l	5	A-T-055w	689	<5	15	4040	30300	23	189	64100	12800	272				10	<5	64100	9	90	WHO	7				1570	584	
Aro >C16-C21 (w)	µg/l	5	A-T-055w	251	9	16	449	2110	55	130	4900	735	116				10	9	4900	10	90	WHO	7				591	423	
Aro >C21-C35 (w)	µg/l	10	A-T-055w	52	<10	<10	143	348	40	39	989	132	32				10	<10	989	8	90	WHO	4				776	392	
Total Aromatics (w)	µg/l	10	A-T-055w	1899	14	62	12000	88700	120	732	127000	40200	512				10	14	127000	10									
TPH (Ali & Aro >C5-C35) (w)	µg/l	10	A-T-055w	1911	14	71	12600	89300	126	769	129000	40600	531				10	14	129000	10									
BTEX - Benzene (w)	µg/l	1	A-T-022w	7	<1	<1	15	4203	2	174	2519	1075	20				10	<1	4203	8	10	EQS	6				No Impact	No Impact	
BTEX - Toluene (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	1848	<1	1	707	336	3				10	<1	1848	6	74	EQS	3				3730	1770	
BTEX - Ethyl Benzene (w)	µg/l	1	A-T-022w	10	<1	<1	<1	77	<1	4	49	58	<1				10	<1	77	5	300	DWS	0						
BTEX - m & p Xylene (w)	µg/l	1	A-T-022w	2	<1	<1	257	874	<1	8	629	171	3				10	<1	874	7	500	DWS	2				3450	2390	
BTEX - o Xylene (w)	µg/l	1	A-T-022w	4	<1	<1	285	326	<1	7	246	91	1				10	<1	326	3	500	DWS	0				3450	2390	
MTBE (w)	µg/l	1	A-T-022w	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1				10	<1	0	0									

Project Name:	Monckton
Project Number:	1015
Area	Geotech Test Data
Matrix	Soils

Hole Number	WS102	WS104	WS106
Top Depth (m)	1	0.5	0.5
Base Depth (m)	1.5	1	1.5
Description	MADE GROUND brown very gravelly very sandy clay. MADE GROUND dark grey very sandy clayey silty gravel. MADE GROUND dark grey very sandy clayey silty gravel.		
Moisture Content (%)	15	12	11
Linear Shrinkage (%)			
Particle Density (Mg/m3)			
Liquid Limit (%)	37	34	35
Plastic Limit (%)	20	17	19
Plasticity Index (%)	17	17	16
Passing 0.425mm (%)	52	37	31
Remarks	Intermediate plasticity CI.	Low plasticity CL.	Intermediate plasticity CI.
PSD - % Passing Sieve Size			
125mm	100	100	100
75mm	100	100	100
63mm	100	100	100
37.5mm	100	100	100
20mm	86	95	93
10mm	76	84	79
6.3mm	69	76	69
3.35mm	63	63	58
2mm	60	55	48
1.18mm	57	47	40
0.6mm	55	39	33
0.3mm	50	33	29
0.212mm	48	30	28
0.15mm	44	29	27
0.063mm	36	37	26
Cobbles %	0	0	0
Gravel %	40	45	52
Sand %	24	28	22
Silt/Clay %	36	27	26

Appendix C

EA CLEA Model

CLEA Software Version 1.071

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Report generated 22/7/2020

Report title Monckton Coking Works



Created by A Wilson at Geo2

BASIC SETTINGS

Land Use Residential with produce (C4SL)

Building Semi-detached house

Receptor Female (res C4SL)

Start age class 1

End age class 6

Exposure Duration 6 years

Soil Sandy loam

Exposure Pathways

Direct soil and dust ingestion



Consumption of homegrown produce



Soil attached to homegrown produce



Dermal contact with indoor dust



Dermal contact with soil



Inhalation of indoor dust



Inhalation of soil dust



Inhalation of indoor vapour



Inhalation of outdoor vapour





Land Use Residential with produce (C4SL)

Receptor Female (res C4SL)

Age Class	Exposure Frequencies (days yr ⁻¹)						Occupation Periods (hr day ⁻¹)		Soil to skin adherence factors (mg cm ⁻²)		Direct soil ingestion rate (g day ⁻¹)	Body weight (kg)	Body height (m)	Inhalation rate (m ³ day ⁻¹)	Max exposed skin factor		Total skin area (m ²)
	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with indoor dust	Dermal contact with soil	Inhalation of dust and vapour, indoor	Inhalation of dust and vapour, outdoor	Indoors	Outdoors	Indoor	Outdoor							
1	180	180	180	170	365	365	23.0	1.0	0.06	0.10	0.10	5.60	0.7	5.4	0.32	0.26	3.43E-01
2	365	365	365	170	365	365	23.0	1.0	0.06	0.10	0.10	9.80	0.8	8.0	0.33	0.26	4.84E-01
3	365	365	365	170	365	365	23.0	1.0	0.06	0.10	0.10	12.70	0.9	8.9	0.32	0.25	5.82E-01
4	365	365	365	170	365	365	23.0	1.0	0.06	0.10	0.10	15.10	0.9	10.1	0.35	0.28	6.36E-01
5	365	365	365	170	365	365	19.0	1.0	0.06	0.10	0.10	16.90	1.0	10.1	0.35	0.28	7.04E-01
6	365	365	365	170	365	365	19.0	1.0	0.06	0.10	0.10	19.70	1.1	10.1	0.33	0.26	7.94E-01
7	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	22.10	1.2	12.0	0.22	0.15	8.73E-01
8	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	25.30	1.2	12.0	0.22	0.15	9.36E-01
9	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	27.50	1.3	12.0	0.22	0.15	1.01E+00
10	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	31.40	1.3	12.0	0.22	0.15	1.08E+00
11	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	35.70	1.4	12.0	0.22	0.14	1.19E+00
12	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	41.30	1.4	15.2	0.22	0.14	1.29E+00
13	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	47.20	1.5	15.2	0.22	0.14	1.42E+00
14	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	51.20	1.6	15.2	0.22	0.14	1.52E+00
15	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	56.70	1.6	15.2	0.21	0.14	1.60E+00
16	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	59.00	1.6	15.2	0.21	0.14	1.63E+00
17	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	70.00	1.6	15.7	0.33	0.27	1.78E+00
18	0	0	0	0	0	0	0.0	0.0	0.00	0.00	0.00	70.90	1.6	13.6	0.33	0.27	1.80E+00

Consumption Rates



Age Class	Consumption rates (g FW kg ⁻¹ bodyweight day ⁻¹) by Produce Group											
	MEAN RATES						90TH PERCENTILE RATES					
	Green veg	Root veg	Tuber veg	Herb. Fruit	Shrub fruit	Tree fruit	Green veg	Root veg	Tuber veg	Herb. Fruit	Shrub fruit	Tree fruit
1	3.47E+00	5.22E+00	9.22E+00	8.90E-01	1.07E+00	1.87E+00	7.12E+00	1.07E+01	1.60E+01	1.83E+00	2.23E+00	3.82E+00
2	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
3	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
4	3.34E+00	1.61E+00	3.14E+00	1.93E+00	2.60E-01	5.84E+00	5.87E+00	2.83E+00	6.60E+00	3.39E+00	4.60E-01	1.03E+01
5	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
6	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
7	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
8	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
9	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
10	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
11	2.54E+00	1.20E+00	2.65E+00	1.25E+00	1.10E-01	2.89E+00	4.53E+00	2.14E+00	4.95E+00	2.24E+00	1.90E-01	5.16E+00
12	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
13	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
14	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
15	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
16	1.03E+00	4.90E-01	1.60E+00	5.10E-01	4.00E-02	1.18E+00	1.87E+00	8.90E-01	3.05E+00	9.30E-01	8.00E-02	2.13E+00
17	1.26E+00	6.00E-01	1.18E+00	6.90E-01	9.00E-02	1.27E+00	2.36E+00	1.12E+00	2.35E+00	1.29E+00	1.80E-01	2.38E+00
18	1.35E+00	6.40E-01	1.25E+00	7.40E-01	1.00E-01	1.36E+00	2.34E+00	1.12E+00	2.36E+00	1.28E+00	1.80E-01	2.37E+00

Top 2 applied? Yes

Where top 2 method is applied, two produce categories use 90th percentile rates, while the remainder use the mean. Produce categories vary on a chemical-by-chemical basis. Where top 2 method is not used, all produce categories for all chemicals assume 90th percentile rates.

Building Semi-detached house**Soil** Sandy loam

Building footprint (m ²)	4.30E+01
Living space air exchange rate (hr ⁻¹)	5.00E-01
Living space height (above ground, m)	4.80E+00
Living space height (below ground, m)	0.00E+00
Pressure difference (soil to enclosed space, Pa)	3.10E+00
Foundation thickness (m)	1.50E-01
Floor crack area (cm ²)	5.25E+02
Dust loading factor (µg m ⁻³)	5.00E+01

Porosity, Total (cm ³ cm ⁻³)	5.30E-01
Porosity, Air-Filled (cm ³ cm ⁻³)	2.00E-01
Porosity, Water-Filled (cm ³ cm ⁻³)	3.30E-01
Residual soil water content (cm ³ cm ⁻³)	1.20E-01
Saturated hydraulic conductivity (cm s ⁻¹)	3.56E-03
van Genuchten shape parameter <i>m</i> (dimensionless)	3.20E-01
Bulk density (g cm ⁻³)	1.21E+00
Threshold value of wind speed at 10m (m s ⁻¹)	7.20E+00
Empirical function (F _x) for dust model (dimensionless)	1.22E+00
Ambient soil temperature (K)	2.83E+02
Soil pH	7.00E+00
Soil Organic Matter content (%)	2.50E+00
Fraction of organic carbon (g g ⁻¹)	1.45E-02
Effective total fluid saturation (unitless)	5.12E-01
Intrinsic soil permeability (cm ²)	4.75E-08
Relative soil air permeability (unitless)	6.42E-01
Effective air permeability (cm ²)	3.05E-08

Soil - Vapour Model

Depth to top of source (no building) (cm)	0
Depth to top of source (beneath building) (cm)	65
Default soil gas ingress rate?	Yes
Soil gas ingress rate ($\text{cm}^3 \text{s}^{-1}$)	2.50E+01
Building ventilation rate ($\text{cm}^3 \text{s}^{-1}$)	2.87E+04
Averaging time surface emissions (yr)	6
Finite vapour source model?	No
Thickness of contaminated layer (cm)	200

Air Dispersion Model

Mean annual windspeed at 10m (m s^{-1})	5.00
Air dispersion factor at height of 0.8m *	2400.00
Air dispersion factor at height of 1.6m *	0.00
Fraction of site cover ($\text{m}^2 \text{m}^{-2}$)	0.75

* Air dispersion factor in $\text{g m}^{-2} \text{s}^{-1}$ per kg m^{-3}

Soil - Plant Model

	Dry weight conversion factor	Homegrown fraction		Soil loading factor	Preparation correction factor
	g DW g^{-1} FW	Average	High		
		dimensionless		g g^{-1} DW	dimensionless
Green vegetables	0.096	0.05	0.33	1.00E-03	2.00E-01
Root vegetables	0.103	0.06	0.40	1.00E-03	1.00E+00
Tuber vegetables	0.210	0.02	0.13	1.00E-03	1.00E+00
Herbaceous fruit	0.058	0.06	0.40	1.00E-03	6.00E-01
Shrub fruit	0.166	0.09	0.60	1.00E-03	6.00E-01
Tree fruit	0.157	0.04	0.27	1.00E-03	6.00E-01

Gardener type Average

CLEA Software Version 1.071

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Report generated 22-Jul-20

Report title Monckton Coking Works

Created by A Wilson at Geo2



RESULTS



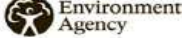
		Assessment Criterion (mg kg ⁻¹)			Ratio of ADE to HCV			Saturation Limit (mg kg ⁻¹)	50% rule?		Top Two applied?	Apply Top 2 Approach to Produce Group					
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal		Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
1	Arsenic (C4SL child)	3.71E+01	5.26E+02	NR	1.00	0.07	NR	NR	No	No	Yes	Yes	No	No	No	No	Yes
2	Lead (C4SL child)	2.01E+02	NR	NR	1.00	NR	NR	NR	No	No	Yes	Yes	No	Yes	No	No	No
3	Nickel	5.90E+02	1.04E+04	NR	1.00	0.03	NR	NR	Yes	Yes	Yes	Yes	Yes	0	0	0	0
4	Benzene (C4SL child)	5.39E-01	1.90E+00	4.20E-01	0.78	0.22	1.00	2.26E+03 (sol)	No	No	Yes	No	Yes	No	No	No	Yes
5	Carbazole	NR	NR	NR	NR	NR	NR	5.44E-03 (vap)	No	No	Yes	No	No	No	No	No	No
6	2-Methylnaphthalene	5.80E+01	NR	NR	1.00	NR	NR	8.00E+02 (sol)	No	No	Yes	No	No	No	No	No	No
7	2-Methylphenol	3.42E+02	NR	NR	1.00	NR	NR	3.25E+04 (sol)	No	No	Yes	No	No	No	No	No	No
8	Phenol	1.74E+03	1.85E+03	8.99E+02	0.52	0.48	1.00	8.15E+04 (vap)	No	No	Yes	No	No	No	No	No	No
9	Benzo[a]pyrene (C4SL child)	4.96E+00	3.83E+01	NR	1.00	0.13	NR	2.28E+00 (vap)	No	No	Yes	No	Yes	Yes	No	No	No
10	Toluene	6.28E+02	2.20E+03	4.89E+02	0.78	0.22	1.00	1.92E+03 (vap)	No	No	Yes	No	No	No	No	No	No
11	Xylene, m-	8.94E+02	2.08E+02	1.69E+02	0.19	0.81	1.00	1.47E+03 (vap)	No	No	Yes	No	No	No	No	No	No
12	Xylene, p-	8.40E+02	1.99E+02	1.61E+02	0.19	0.81	1.00	1.35E+03 (sol)	No	No	Yes	No	No	No	No	No	No
13	Xylene, o-	8.16E+02	2.22E+02	1.74E+02	0.21	0.79	1.00	1.12E+03 (sol)	No	No	Yes	No	No	No	No	No	No
14	Ethylbenzene	4.67E+02	6.31E+02	2.68E+02	0.57	0.43	1.00	1.22E+03 (vap)	No	No	Yes	No	No	No	No	No	No
15	>C8-C10 Aliphatic TPH Fraction	3.89E+03	7.51E+01	7.47E+01	0.01	0.99	1.00	1.90E+02 (vap)	Yes	Yes	Yes	No	No	No	No	No	No
16	>C10-C12 Aliphatic TPH Fraction	5.91E+03	3.79E+02	3.73E+02	0.03	0.97	1.00	1.18E+02 (vap)	Yes	Yes	Yes	No	No	No	No	No	No
17	>C5-C7 Aromatic TPH Fraction	3.29E+02	7.99E+02	2.33E+02	0.71	0.29	1.00	2.26E+03 (sol)	No	No	Yes	No	No	No	No	No	No
18	>C7-C8 Aromatic TPH Fraction	6.28E+02	2.20E+03	4.89E+02	0.78	0.22	1.00	1.91E+03 (vap)	No	No	Yes	No	No	No	No	No	No
19	>C8-C10 Aromatic TPH Fraction	2.41E+02	1.33E+02	1.10E+02	0.30	0.70	1.00	1.50E+03 (vap)	Yes	Yes	Yes	No	No	No	No	No	No
20	>C10-C12 Aromatic TPH Fraction	3.37E+02	7.32E+02	2.90E+02	0.75	0.25	1.00	8.99E+02 (sol)	Yes	Yes	Yes	No	No	No	No	No	No

[illegible]



		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg ⁻¹	mg m ⁻³	mg kg ⁻¹	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg m ⁻³	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW	mg kg ⁻¹ FW
1	Arsenic (C4SL child)	99.9	0.1	0.0	100.0	3.71E+01	NR	1.85E+01	1.58E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-02	1.48E-02	8.53E-03	1.22E-02	7.42E-03	4.08E-02
2	Lead (C4SL child)	100.0	0.0	0.0	100.0	2.01E+02	NR	1.00E+02	8.55E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.42E-01	8.08E-01	1.47E+00	1.50E-01	4.12E-02	4.60E-02
3	Nickel	99.9	0.1	0.0	100.0	5.90E+02	NR	0.00E+00	2.51E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.24E+00	2.54E+00	1.12E+00	1.48E+00	1.48E+00	2.01E+00
4	Benzene (C4SL child)	77.1	21.4	1.5	100.0	4.20E-01	3.83E+01	2.10E-01	1.79E-10	0.00E+00	1.12E-03	1.83E-06	0.00E+00	4.40E-01	7.79E-01	3.23E-01	0.00E+00	0.00E+00	7.57E-01
5	Carbazole	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	2-Methylnaphthalene	99.1	0.9	0.0	100.0	5.80E+01	1.10E+01	2.90E+01	2.47E-08	0.00E+00	2.59E-04	9.86E-06	0.00E+00	1.08E+01	1.44E+01	4.07E+00	0.00E+00	0.00E+00	1.83E+00
7	2-Methylphenol	89.6	10.4	0.0	100.0	3.42E+02	2.35E+00	1.71E+02	1.46E-07	0.00E+00	1.86E-04	5.76E-05	0.00E+00	1.51E+02	2.34E+02	1.13E+02	0.00E+00	0.00E+00	2.84E+02
8	Phenol	81.6	18.4	0.0	100.0	8.99E+02	5.08E+00	4.49E+02	3.83E-07	0.00E+00	4.25E-03	2.11E-04	0.00E+00	4.81E+02	8.64E+02	5.19E+02	0.00E+00	0.00E+00	9.82E+02
9	Benzo[a]pyrene (C4SL child)	100.0	0.0	0.0	100.0	4.96E+00	4.67E-06	2.48E+00	2.11E-09	0.00E+00	4.10E-09	2.47E-08	0.00E+00	2.04E-03	8.82E-03	4.41E-03	2.52E-03	2.79E-05	2.32E-04
10	Toluene	91.0	8.4	0.6	100.0	4.89E+02	1.73E+04	2.44E+02	2.08E-07	0.00E+00	4.67E-01	1.25E-03	0.00E+00	3.53E+02	5.31E+02	1.59E+02	0.00E+00	0.00E+00	3.56E+02
11	Xylene, m-	96.1	3.7	0.3	100.0	1.69E+02	2.55E+03	8.43E+01	7.17E-08	0.00E+00	6.43E-02	2.68E-04	0.00E+00	8.31E+01	1.17E+02	3.13E+01	0.00E+00	0.00E+00	4.56E+01
12	Xylene, p-	95.7	4.0	0.3	100.0	1.61E+02	2.54E+03	8.04E+01	6.84E-08	0.00E+00	6.41E-02	2.61E-04	0.00E+00	8.29E+01	1.18E+02	3.21E+01	0.00E+00	0.00E+00	4.87E+01
13	Xylene, o-	95.6	4.2	0.2	100.0	1.74E+02	2.48E+03	8.72E+01	7.42E-08	0.00E+00	6.23E-02	2.68E-04	0.00E+00	9.15E+01	1.30E+02	3.60E+01	0.00E+00	0.00E+00	5.61E+01
14	Ethylbenzene	95.6	4.0	0.3	100.0	2.68E+02	5.51E+03	1.34E+02	1.14E-07	0.00E+00	1.39E-01	4.97E-04	0.00E+00	1.38E+02	1.96E+02	5.35E+01	0.00E+00	0.00E+00	8.13E+01
15	>C8-C10 Aliphatic TPH Fraction	98.4	0.1	1.5	100.0	7.47E+01	6.97E+03	3.74E+01	3.18E-08	0.00E+00	2.22E-01	3.51E-04	0.00E+00	8.53E-01	1.65E+00	1.43E+00	0.00E+00	0.00E+00	2.26E-02
16	>C10-C12 Aliphatic TPH Fraction	99.7	0.0	0.3	100.0	3.73E+02	6.88E+03	1.87E+02	1.59E-07	0.00E+00	2.19E-01	7.80E-04	0.00E+00	1.68E-01	1.07E+00	1.84E+00	0.00E+00	0.00E+00	8.70E-04
17	>C5-C7 Aromatic TPH Fraction	77.1	21.4	1.5	100.0	2.33E+02	2.13E+04	1.17E+02	9.92E-08	0.00E+00	6.23E-01	1.02E-03	0.00E+00	2.44E+02	4.32E+02	1.79E+02	0.00E+00	0.00E+00	4.20E+02
18	>C7-C8 Aromatic TPH Fraction	91.0	8.4	0.6	100.0	4.89E+02	1.73E+04	2.44E+02	2.08E-07	0.00E+00	4.67E-01	1.25E-03	0.00E+00	3.53E+02	5.31E+02	1.59E+02	0.00E+00	0.00E+00	3.56E+02
19	>C8-C10 Aromatic TPH Fraction	98.6	1.2	0.2	100.0	1.10E+02	1.19E+03	5.50E+01	4.68E-08	0.00E+00	3.81E-02	1.77E-04	0.00E+00	2.44E+01	3.29E+01	8.85E+00	0.00E+00	0.00E+00	6.58E+00
20	>C10-C12 Aromatic TPH Fraction	99.2	0.7	0.0	100.0	2.90E+02	5.70E+02	1.45E+02	1.23E-07	0.00E+00	1.82E-02	1.98E-04	0.00E+00	4.57E+01	6.11E+01	1.77E+01	0.00E+00	0.00E+00	8.61E+00

[illegible]

		Average Daily Exposure (mg kg ⁻¹ bw day ⁻¹)							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Arsenic (C4SL child)	2.75E-04	2.12E-05	3.68E-06	6.13E-07	0.00E+00	0.00E+00	0.00E+00	91.70	7.08	1.23	0.00	0.00	0.00	0.00	0.00
2	Lead (C4SL child)	8.94E-04	5.04E-04	0.00E+00	2.13E-06	0.00E+00	0.00E+00	0.00E+00	63.85	35.99	0.00	0.15	0.00	0.00	0.00	0.00
3	Nickel	4.38E-03	1.62E-03	5.67E-06	1.71E-07	0.00E+00	7.31E-03	3.64E-06	36.49	13.46	0.05	0.00	0.00	0.00	49.98	0.02
4	Benzene (C4SL child)	3.12E-06	4.41E-04	1.39E-07	6.94E-09	7.30E-04	0.00E+00	0.00E+00	0.27	37.53	0.01	0.00	62.18	0.00	0.00	0.00
5	Carbazole	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2-Methylnaphthalene	4.30E-04	3.48E-03	2.49E-05	9.59E-07	1.69E-04	0.00E+00	6.06E-05	10.76	87.11	0.62	0.00	0.00	0.00	0.00	1.52
7	2-Methylphenol	2.54E-03	9.72E-02	1.13E-04	5.66E-06	1.23E-04	0.00E+00	3.84E-05	2.54	97.18	0.11	0.01	0.12	0.00	0.00	0.04
8	Phenol	6.67E-03	3.44E-01	8.92E-04	1.49E-05	2.77E-03	1.97E-02	2.42E-03	1.77	91.38	0.24	0.00	0.73	0.00	5.23	0.64
9	Benzo[a]pyrene (C4SL child)	3.68E-05	3.03E-06	2.13E-06	8.19E-08	3.39E-09	0.00E+00	0.00E+00	87.52	7.20	5.07	0.20	0.01	0.00	0.00	0.00
10	Toluene	3.62E-03	1.69E-01	1.62E-04	8.08E-06	3.04E-01	5.63E-04	3.15E-02	0.71	33.27	0.03	0.00	59.68	0.01	0.11	6.19
11	Xylene, m-	1.25E-03	3.25E-02	5.57E-05	2.79E-06	4.18E-02	6.19E-04	8.49E-03	1.48	38.37	0.07	0.00	49.33	0.01	0.73	10.02
12	Xylene, p-	1.19E-03	3.31E-02	5.31E-05	2.66E-06	4.17E-02	6.19E-04	8.49E-03	1.40	38.88	0.06	0.00	48.94	0.01	0.73	9.97
13	Xylene, o-	1.29E-03	3.70E-02	5.76E-05	2.88E-06	4.05E-02	6.19E-04	8.49E-03	1.47	42.04	0.07	0.00	46.06	0.01	0.70	9.65
14	Ethylbenzene	1.99E-03	5.52E-02	8.87E-05	4.44E-06	9.02E-02	2.81E-04	7.88E-03	1.28	35.47	0.06	0.00	57.94	0.01	0.18	5.06
15	>C8-C10 Aliphatic TPH Fraction	5.54E-04	3.81E-04	2.47E-05	1.24E-06	1.44E-01	5.62E+95	6.06E+95	0.19	0.13	0.01	0.00	49.67	0.00	0.33	49.67
16	>C10-C12 Aliphatic TPH Fraction	2.77E-03	2.64E-04	1.23E-04	6.17E-06	1.43E-01	5.62E+95	6.06E+95	0.95	0.09	0.04	0.00	48.91	0.01	1.08	48.92
17	>C5-C7 Aromatic TPH Fraction	1.73E-03	1.56E-01	7.71E-05	3.85E-06	4.05E-01	1.69E-04	1.21E-02	0.30	27.12	0.01	0.00	70.42	0.01	0.03	2.11
18	>C7-C8 Aromatic TPH Fraction	3.62E-03	1.69E-01	1.62E-04	8.08E-06	3.04E-01	5.63E-04	3.15E-02	0.71	33.27	0.03	0.00	59.68	0.01	0.11	6.19
19	>C8-C10 Aromatic TPH Fraction	8.16E-04	8.29E-03	3.64E-05	1.82E-06	2.48E-02	5.62E+95	6.06E+95	1.20	12.22	0.05	0.00	36.51	0.01	13.48	36.52
20	>C10-C12 Aromatic TPH Fraction	2.15E-03	1.49E-02	9.57E-05	4.79E-06	1.19E-02	5.62E+95	6.06E+95	3.70	25.72	0.16	0.01	20.40	0.01	29.58	20.42

[illegible]



		Oral Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day $^{-1}$)		Inhalation Health Criteria Value ($\mu\text{g kg}^{-1}$ BW day $^{-1}$)		Oral Mean Daily Intake ($\mu\text{g day}^{-1}$)	Inhalation Mean Daily Intake ($\mu\text{g day}^{-1}$)	Air-water partition coefficient (K_{aw}) ($\text{cm}^3 \text{cm}^{-3}$)	Coefficient of Diffusion in Air ($\text{m}^2 \text{s}^{-1}$)	Coefficient of Diffusion in Water ($\text{m}^2 \text{s}^{-1}$)	$\log K_{oc}$ ($\text{cm}^3 \text{g}^{-1}$)	$\log K_{ow}$ (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
1	Arsenic (C4SL child)	ID	0.3	ID	0.0087	NR	NR	NR	NR	NR	NR	NR	0.03	0.5	1	1	1
2	Lead (C4SL child)	ID	1.4	NR	0	NR	NR	NR	NR	NR	NR	NR	0	0.5	1	0.6	0.64
3	Nickel	TDI	12	TDI	0.006	130	0.06	NR	NR	NR	NR	NR	0.005	0	0	1	1
4	Benzene (C4SL child)	ID	0.57	ID	3.3	NR	NR	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
5	Carbazole	NR	0	NR	0	0	0	1.15E-03	5.39E-06	4.40E-10	2.89	3.6	0.1	0.5	10	1	1
6	2-Methylnaphthalene	TDI	4	NR	NR	0	1	6.06E-03	6.03E-06	4.75E-10	3.34	4	0.13	0.5	10	1	1
7	2-Methylphenol	TDI	100	NR	0	0	0.634	1.80E-05	7.17E-06	5.67E-10	2.21	1.98	0.1	0.5	10	1	1
8	Phenol	TDI	700	TDI	10	350	40	8.35E-06	7.90E-06	6.36E-10	1.92	1.48	0.3	0.5	1	1	1
9	Benzo[a]pyrene (C4SL child)	ID	0.042	ID	0.00066	NR	NR	1.76E-06	4.38E-06	3.67E-10	5.11	6.18	0.13	0.5	1	1	1
10	Toluene	TDI	223	TDI	1400	10	520	1.15E-01	7.78E-06	5.88E-10	2.31	2.73	0.1	0.5	10	1	1
11	Xylene, m-	TDI	180	TDI	60	11	140	1.12E-01	7.03E-06	5.31E-10	2.69	3.2	0.1	0.5	10	1	1
12	Xylene, p-	TDI	180	TDI	60	11	140	1.07E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
13	Xylene, o-	TDI	180	TDI	60	11	140	9.20E-02	7.01E-06	5.31E-10	2.63	3.12	0.1	0.5	10	1	1
14	Ethylbenzene	TDI	100	TDI	220	5	130	1.39E-01	7.04E-06	5.31E-10	2.65	3.15	0.1	0.5	10	1	1
15	>C8-C10 Aliphatic TPH Fraction	TDI	100	TDI	290	9.99E+99	9.99E+99	4.15E+01	1.00E-05	1.00E-09	4.48	5.22	0.1	0.5	10	1	1
16	>C10-C12 Aliphatic TPH Fraction	TDI	100	TDI	290	9.99E+99	9.99E+99	6.44E+01	1.00E-05	1.00E-09	5.38	6.3	0.1	0.5	10	1	1
17	>C5-C7 Aromatic TPH Fraction	TDI	223	TDI	1400	3	200	1.16E-01	8.77E-06	6.64E-10	1.83	2.13	0.1	0.5	10	1	1
18	>C7-C8 Aromatic TPH Fraction	TDI	223	TDI	1400	10	520	1.15E-01	7.78E-06	5.88E-10	2.31	2.73	0.1	0.5	10	1	1
19	>C8-C10 Aromatic TPH Fraction	TDI	40	TDI	60	9.99E+99	9.99E+99	2.53E-01	1.00E-05	1.00E-09	3.2	3.69	0.1	0.5	10	1	1
20	>C10-C12 Aromatic TPH Fraction	TDI	40	TDI	60	9.99E+99	9.99E+99	7.22E-02	1.00E-05	1.00E-09	3.4	3.93	0.1	0.5	10	1	1

[illegible]



		Sol-to-water partition coefficient ($\text{cm}^3 \text{g}^{-1}$)	Vapour pressure (Pa)	Water solubility (mg L^{-1})	Sol-to-plant concentration factor for green vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Sol-to-plant concentration factor for root vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Sol-to-plant concentration factor for tuber vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Sol-to-plant concentration factor for herbaceous fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Sol-to-plant concentration factor for shrub fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Sol-to-plant concentration factor for tree fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)
1	Arsenic (C4SL child)	5.00E+02	NR	1.25E+06	0.00043 fw	0.0004 fw	0.00023 fw	0.00033 fw	0.0002 fw	0.0011 fw
2	Lead (C4SL child)	1.00E+03	NR	2.96E+05	0.00419 fw	0.00402 fw	0.00731 fw	0.00074 fw	0.00020 fw	0.00022 fw
3	Nickel	5.00E+02	NR	2.50E+06	0.0038 fw	0.0043 fw	0.0019 fw	0.0025 fw	0.0025 fw	0.0034 fw
4	Benzene (C4SL child)	9.80E-01	6.24E+03	1.78E+03	model	model	model	0.00E+00	0.00E+00	model
5	Carbazole	1.13E+01	7.64E-06	1.16E+00	Model	Model	Model	Model	Model	Model
6	2-Methylnaphthalene	3.17E+01	3.41E+00	2.50E+01	model	model	model	model	model	model
7	2-Methylphenol	2.35E+00	1.53E+01	1.24E+04	Model	Model	Model	Model	Model	Model
8	Phenol	1.21E+00	1.15E+01	8.41E+04	model	model	model	0.00E+00	0.00E+00	model
9	Benzo[a]pyrene (C4SL child)	1.87E+03	2.00E-08	3.80E-03	0.00041 fw	0.00178 fw	0.00088 fw	0.00050 fw	0.00000 fw	0.00004 fw
10	Toluene	2.96E+00	1.73E+03	5.90E+02	model	model	model	0.00E+00	0.00E+00	model
11	Xylene, m-	7.10E+00	4.95E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
12	Xylene, p-	6.48E+00	4.75E+02	2.00E+02	model	model	model	0.00E+00	0.00E+00	model
13	Xylene, o-	6.19E+00	3.86E+02	1.73E+02	model	model	model	0.00E+00	0.00E+00	model
14	Ethylbenzene	6.48E+00	5.53E+02	1.80E+02	model	model	model	0.00E+00	0.00E+00	model
15	>C8-C10 Aliphatic TPH Fraction	4.38E+02	3.20E+02	4.27E-01	model	model	model	model	model	model
16	>C10-C12 Aliphatic TPH Fraction	3.48E+03	3.21E+01	3.39E-02	model	model	model	model	model	model
17	>C5-C7 Aromatic TPH Fraction	9.80E-01	6.24E+03	1.78E+03	model	model	model	model	model	model
18	>C7-C8 Aromatic TPH Fraction	2.96E+00	1.73E+03	5.90E+02	model	model	model	model	model	model
19	>C8-C10 Aromatic TPH Fraction	2.30E+01	3.20E+02	6.46E+01	model	model	model	model	model	model
20	>C10-C12 Aromatic TPH Fraction	3.64E+01	3.21E+01	2.45E+01	model	model	model	model	model	model

[illegible]

Appendix D

EA RTM Worksheets



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	Adam Wilson		
Date:	19.7.20	Version:	Lineside Dyke
Contaminant	Phenol		
Target Concentration (C_T)	0.0077	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Phenol
0.0077 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+00

g/cm³

Henry's Law constant

H

1.64E-05

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

2.88E+01

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.30E-01

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.31E-03

mg/kg

(for comparison with soil analyses)

or

0.0077

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: Adam Wilson

Date: 19.7.20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Phenol
0.0077

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-08

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.09E+00

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

3.28E-01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: Adam Wilson
Date: 19.7.20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Phenol		from Level 1
Target Concentration	C _T	0.0077	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	10	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.61E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.84E+00	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.78E-02	partitioning equation.
			Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.88E+01 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.30E-01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

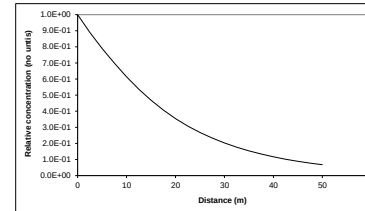
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.35E-01
2.5	8.89E-01	2.09E-01
5.0	7.90E-01	1.85E-01
7.5	6.99E-01	1.64E-01
10.0	6.14E-01	1.44E-01
12.5	5.37E-01	1.26E-01
15.0	4.68E-01	1.10E-01
17.5	4.07E-01	9.56E-02
20.0	3.54E-01	8.32E-02
22.5	3.08E-01	7.23E-02
25.0	2.68E-01	6.28E-02
27.5	2.33E-01	5.47E-02
30.0	2.03E-01	4.75E-02
32.5	1.76E-01	4.14E-02
35.0	1.54E-01	3.61E-02
37.5	1.34E-01	3.14E-02
40.0	1.17E-01	2.74E-02
42.5	1.02E-01	2.39E-02
45.0	8.89E-02	2.08E-02
47.5	7.75E-02	1.82E-02
50.0	6.78E-02	1.59E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: Adam Wilson

Date: 19.7.20

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Phenol		from Level 1
Target Concentration	C _T	7.70E-03	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state	Equations in HRA publication
-------------------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.00E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+01	days	
Calculated decay rate	λ	6.93E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.30E-01	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Variable

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	2.64E+00	fraction
Decay rate used	λ	2.62E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	4.49E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	2.31E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.32E+01	

Remedial Targets

Remedial Target	3.33E-01	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C _{1D} /C ₀	2.31E-01	mg/l Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

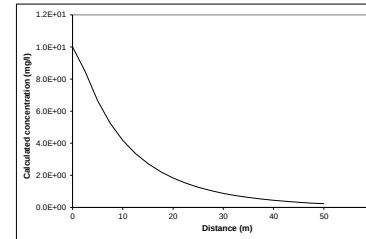
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	8.00E-03 fraction
Organic carbon partition coefficient	Koc	2.88E+01 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	
Sorption coefficient for ionised species	K _{oc, i}	
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	
Soil water partition coefficient	Kd	2.30E-01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: Adam Wilson
Date: 19.7.20
Version: Limeside Dyke

Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance	Concentration
	mg/l
0	1.0E+01
2.5	8.48E+00
5.0	6.65E+00
7.5	5.24E+00
10.0	4.18E+00
12.5	3.37E+00
15.0	2.73E+00
17.5	2.23E+00
20.0	1.83E+00
22.5	1.52E+00
25.0	1.26E+00
27.5	1.05E+00
30.0	8.77E-01
32.5	7.36E-01
35.0	6.19E-01
37.5	5.23E-01
40.0	4.42E-01
42.5	3.75E-01
45.0	3.19E-01
47.5	2.71E-01
50.0	2.31E-01



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Selenium		
Target Concentration (C_T)	0.01	mg/l	Origin of C_T: DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Selenium
0.01 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

5.00E+01 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.00E-01 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

4.07E-03 mg/kg

(for comparison with soil analyses)

or

0.01 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Selenium
0.01

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.42E+00

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

5.77E-01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Selenium		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.00E+00	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	8.13E-01	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	7.10E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E+01	l/kg
----------------------------------	----	----------	------

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
---------------------------------------	-----	--	----------

Organic carbon partition coefficient	Koc		l/kg
--------------------------------------	-----	--	------

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	K _{oc,ij}		l/kg
--	--------------------	--	------

Sorption coefficient for ionised species	K _{oc,i}		l/kg
--	-------------------	--	------

pH value	pH		
----------	----	--	--

Acid dissociation constant	pKa		
----------------------------	-----	--	--

Fraction of organic carbon in aquifer	foc		fraction
---------------------------------------	-----	--	----------

Soil water partition coefficient	Kd	5.00E+01	l/kg
----------------------------------	----	----------	------

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

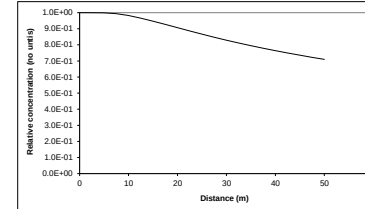
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀ax)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	Relative concentration	Concentration
From calculation sheet		
Distance	concentration	mg/l
0	1.0E+00	1.56E-01
2.5	1.00E+00	1.56E-01
5.0	9.99E-01	1.56E-01
7.5	9.94E-01	1.55E-01
10.0	9.82E-01	1.53E-01
12.5	9.66E-01	1.51E-01
15.0	9.47E-01	1.48E-01
17.5	9.27E-01	1.45E-01
20.0	9.06E-01	1.41E-01
22.5	8.86E-01	1.38E-01
25.0	8.66E-01	1.35E-01
27.5	8.47E-01	1.32E-01
30.0	8.29E-01	1.29E-01
32.5	8.12E-01	1.27E-01
35.0	7.95E-01	1.24E-01
37.5	7.79E-01	1.22E-01
40.0	7.64E-01	1.19E-01
42.5	7.50E-01	1.17E-01
45.0	7.36E-01	1.15E-01
47.5	7.23E-01	1.13E-01
50.0	7.10E-01	1.11E-01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: LlinesDyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Selenium		from Level 1
Target Concentration	C _T	1.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.00E-02	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	5.00E+01	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	3.58E+02	fraction
Decay rate used	λ	1.96E-104	d ⁻¹
Rate of contaminant flow due to retardation	u	3.32E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	4.91E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.07E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

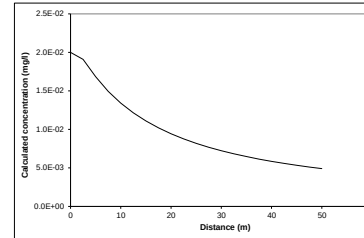
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	5.00E+01	l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.00E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	5.00E+00	m
Transverse dispersivity	az	5.00E+00	5.00E-01	5.00E-01	m
Vertical dispersivity	ay	5.00E+00	5.00E-02	5.00E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke

Remedial Targets

Remedial Target	4.07E-02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{ED} /C ₀	4.91E-03	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.





Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Nickel		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Nickel
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

5.00E+02 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.00E+00 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.00E-01 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T **Nickel** from Level 1
0.05 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Infiltration
Area of contaminant source

Variable

Inf
A

Value

1.77E-04
5.00E+03

Unit

m/d
m²

Source of parameter value

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

7.09E+00
or
2.84E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

Cc

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Nickel		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	198	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days
Calculated decay rate	λ	7.00E-102	days ⁻¹
Width of plume in aquifer at source	Sz	1.50E+01	m
Plume thickness in aquifer at source	Sy	7.00E+00	m
Bulk density of aquifer materials	ρ	2.14E+01	g/cm ³
Effective porosity of aquifer	n	3.00E-01	fraction
Hydraulic gradient	i	8.06E-02	fraction
Hydraulic conductivity of saturated aquifer	K	4.45E+00	m/d
Distance to compliance point	x	5.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z		m
Distance (depth) to compliance point perpendicular to flow direction	y		m
Time since pollutant entered groundwater	t	1.00E+06	days
time variant options only			
Parameters values determined from options			
Partition coefficient	Kd	5.00E+02	l/kg
Longitudinal dispersivity	ax	5.000	m
Transverse dispersivity	az	0.500	m
Vertical dispersivity	ay	0.050	m

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	1.20E+00 m/d
Retardation factor	Rf	3.57E+04
Decay rate used	λ	1.96E-106 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	8.06E-02
Rate of contaminant flow due to retardation	u	3.35E-05 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.70E-01
Attenuation factor (C ₀ /C ₁₀₀)	AF	5.88E+00
Calculated soil leachate concentration	Co	4.94E+01 mg/l

Remedial Targets

Level 3 Remedial Target	4.17E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks			This assumes Level 1 Remedial Target is based on Target Concentration.
	1.67E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.70E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,rel} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 5.00E+02 l/kg

Soil water partition coefficient Kd 5.00E+02 l/kg

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Soil water partition coefficient Kd 5.00E+02 l/kg

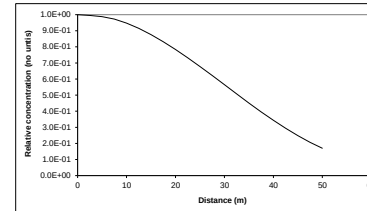
Soil water partition coefficient Kd 5.00E+02 l/kg

Soil water partition coefficient Kd 5.00E+02 l/kg

Soil water partition coefficient Kd 5.00E+02 l/kg

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	3.48E-01
2.5	9.95E-01	3.47E-01
5.0	9.88E-01	3.44E-01
7.5	9.72E-01	3.39E-01
10.0	9.48E-01	3.30E-01
12.5	9.15E-01	3.19E-01
15.0	8.76E-01	3.05E-01
17.5	8.32E-01	2.90E-01
20.0	7.83E-01	2.73E-01
22.5	7.32E-01	2.55E-01
25.0	6.78E-01	2.36E-01
27.5	6.22E-01	2.17E-01
30.0	5.65E-01	1.97E-01
32.5	5.08E-01	1.77E-01
35.0	4.51E-01	1.57E-01
37.5	3.96E-01	1.38E-01
40.0	3.44E-01	1.20E-01
42.5	2.94E-01	1.03E-01
45.0	2.49E-01	8.66E-02
47.5	2.07E-01	7.22E-02
50.0	1.70E-01	5.93E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Nickel		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.26E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	5.00E+02	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	3.57E+03	fraction
Decay rate used	λ	1.96E-105	d ⁻¹
Rate of contaminant flow due to retardation	u	3.33E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	5.55E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.07E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

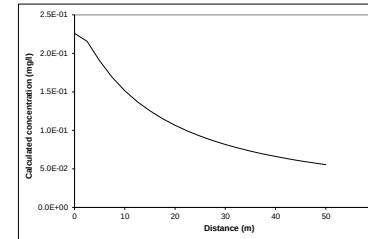
Entry if specify partition coefficient (option)	Kd	5.00E+02	l/kg
Entry for ionic organic chemicals (option)	K _{oc, n}		l/kg
Entry for non-polar organic chemicals (option)	K _{oc, n}		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K _{oc, n}		l/kg
Sorption coefficient for ionised species	K _{oc, n}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	5.00E+00	5.00E+00	m
Transverse dispersivity	az	5.00E-01	5.00E-01	5.00E-01	5.00E-01	m
Vertical dispersivity	ay	5.00E-02	5.00E-02	5.00E-02	5.00E-02	m

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.414}; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	Concentration
Distance	Concentration

0	2.3E-01
2.5	2.16E-01
5.0	1.90E-01
7.5	1.69E-01
10.0	1.52E-01
12.5	1.37E-01
15.0	1.25E-01
17.5	1.15E-01
20.0	1.07E-01
22.5	9.91E-02
25.0	9.26E-02
27.5	8.68E-02
30.0	8.18E-02
32.5	7.72E-02
35.0	7.31E-02
37.5	6.95E-02
40.0	6.61E-02
42.5	6.31E-02
45.0	6.04E-02
47.5	5.78E-02
50.0	5.55E-02

Remedial Targets

Remedial Target	2.04E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
Concentration of contaminant at compliance point after	C _{1D} /C ₀	5.55E-02
		1.0E+06

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Lead		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Lead
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

1.58E+04 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

1.26E+02 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

6.32E+00 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Lead
0.05

from Level 1
from Level 1

mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor DF

1.42E+02

Level 2 Remedial Target

7.09E+00

mg/l

or

8.96E+02

mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Lead		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	584	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days
Calculated decay rate	λ	7.00E-102	days ⁻¹
Width of plume in aquifer at source	Sz	1.50E+01	m
Plume thickness in aquifer at source	Sy	7.00E+00	m
Bulk density of aquifer materials	ρ	2.14E+01	g/cm ³
Effective porosity of aquifer	n	3.00E-01	fraction
Hydraulic gradient	i	8.06E-02	fraction
Hydraulic conductivity of saturated aquifer	K	4.45E+00	m/d
Distance to compliance point	x	5.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z		m
Distance (depth) to compliance point perpendicular to flow direction	y		m
Time since pollutant entered groundwater	t	1.00E+06	days
time variant options only			
Parameters values determined from options			
Partition coefficient	Kd	1.58E+04	l/kg
Longitudinal dispersivity	ax	5.000	m
Transverse dispersivity	az	0.500	m
Vertical dispersivity	ay	0.050	m

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	1.20E+00 m/d
Retardation factor	Rf	1.13E+06
Decay rate used	λ	6.21E-108 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	8.06E-02
Rate of contaminant flow due to retardation	u	1.06E-06 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00
Attenuation factor (C ₀ /C ₁₀₀)	AF	reakthrough at or
Calculated soil leachate concentration	Co	4.62E+00 mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	partitioning equation.
		fraction	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 1.58E+04 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,li} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.58E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

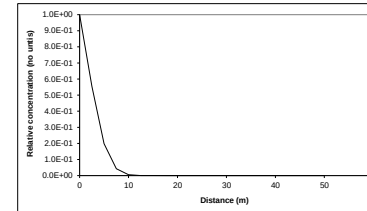
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	3.26E-02
2.5	5.55E-01	1.81E-02
5.0	1.98E-01	6.46E-03
7.5	4.29E-02	1.40E-03
10.0	5.45E-03	1.77E-04
12.5	3.98E-04	1.30E-05
15.0	1.66E-05	5.40E-07
17.5	2.06E-07	6.72E-09
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Lead		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	7.00E-03	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	1.58E+04	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.13E+05	fraction
Decay rate used	λ	6.21E-107	d ⁻¹
Rate of contaminant flow due to retardation	u	1.05E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.03E-07	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	6.80E+04	

Select Method for deriving Partition Co-efficient (using pull down menu)

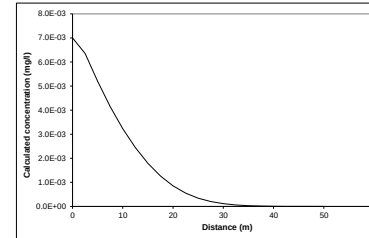
User specified value for partition coefficient

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	1.58E+04 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	1.58E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke

Remedial Targets

Remedial Target	3.40E+03	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.03E-07	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.





Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson	Version:	Lineside Dyke
Date:	15-Jul-20		
Contaminant	Arsenic		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Arsenic
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

2.51E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.01E+01 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

1.00E+00 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Arsenic
0.05

from Level 1
from Level 1

mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
8.00E-03

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor DF

1.19E+02

Level 2 Remedial Target

5.96E+00

mg/l

or

1.20E+02

mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.19E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	36	mg/kg	
Enter soil concentration	9.90E+100	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	3.49E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	7.01E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.71E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,rel} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

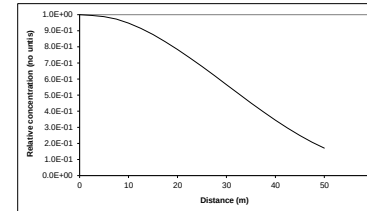
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.50E-02
2.5	9.95E-01	1.50E-02
5.0	9.88E-01	1.48E-02
7.5	9.73E-01	1.46E-02
10.0	9.48E-01	1.42E-02
12.5	9.15E-01	1.38E-02
15.0	8.76E-01	1.32E-02
17.5	8.32E-01	1.25E-02
20.0	7.84E-01	1.18E-02
22.5	7.32E-01	1.10E-02
25.0	6.78E-01	1.02E-02
27.5	6.22E-01	9.35E-03
30.0	5.65E-01	8.50E-03
32.5	5.08E-01	7.64E-03
35.0	4.52E-01	6.79E-03
37.5	3.97E-01	5.96E-03
40.0	3.44E-01	5.18E-03
42.5	2.95E-01	4.43E-03
45.0	2.49E-01	3.75E-03
47.5	2.08E-01	3.12E-03
50.0	1.71E-01	2.57E-03

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Arsenic		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	6.40E-02	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	0.00E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	7.00E-102	d ⁻¹
Rate of contaminant flow due to retardation	u	1.19E+00	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.57E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.07E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

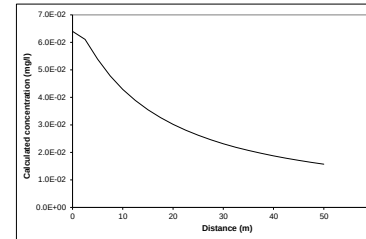
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	K _d	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	f _{oc}	0.00E+00 fraction
Organic carbon partition coefficient	K _{oc}	2.51E+03 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	l/kg
Sorption coefficient for ionised species	K _{oc, i}	l/kg
pH value	pH	
acid dissociation constant	pK _a	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	K _d	0.00E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Linesside Dyke

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	6.4E-02
2.5	6.11E-02
5.0	5.39E-02
7.5	4.78E-02
10.0	4.29E-02
12.5	3.89E-02
15.0	3.55E-02
17.5	3.26E-02
20.0	3.02E-02
22.5	2.81E-02
25.0	2.62E-02
27.5	2.46E-02
30.0	2.32E-02
32.5	2.19E-02
35.0	2.07E-02
37.5	1.97E-02
40.0	1.87E-02
42.5	1.79E-02
45.0	1.71E-02
47.5	1.64E-02
50.0	1.57E-02

Remedial Targets

Remedial Target	2.04E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.57E-02	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C10-C12 (Naphthalene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C10-C12 (Naphthalene)
0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 2.00E-02 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 2.51E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pK_a
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 2.01E+01 l/kg Calculated value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	1.81E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C10-C12 (Naphthalene)
0.09 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Infiltration
Area of contaminant source

Variable

Inf
A

Value

1.77E-04
5.00E+03

Unit

m/d
m²

Source of parameter value

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.28E+01

mg/l

or

2.56E+02

mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C10-C12 (Naphtha)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	109000	mg/kg	
Enter soil concentration	1.29E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.24E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.50E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	5.70E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+03 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

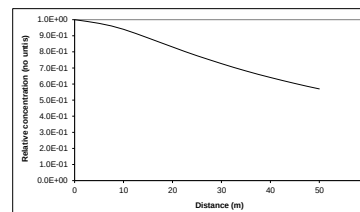
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.83E+01
2.5	9.89E-01	3.79E+01
5.0	9.77E-01	3.74E+01
7.5	9.62E-01	3.68E+01
10.0	9.40E-01	3.60E+01
12.5	9.14E-01	3.50E+01
15.0	8.87E-01	3.39E+01
17.5	8.58E-01	3.28E+01
20.0	8.30E-01	3.18E+01
22.5	8.03E-01	3.07E+01
25.0	7.76E-01	2.97E+01
27.5	7.51E-01	2.87E+01
30.0	7.27E-01	2.78E+01
32.5	7.03E-01	2.69E+01
35.0	6.82E-01	2.61E+01
37.5	6.61E-01	2.53E+01
40.0	6.41E-01	2.45E+01
42.5	6.22E-01	2.38E+01
45.0	6.04E-01	2.31E+01
47.5	5.85E-01	2.24E+01
50.0	5.70E-01	2.18E+01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C10-C12 Naphthalene	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.77E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.29E+02	days	
Calculated decay rate	λ	5.37E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.01E+01	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.44E+02	fraction
Decay rate used	λ	3.73E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	8.23E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	9.39E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	5.08E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

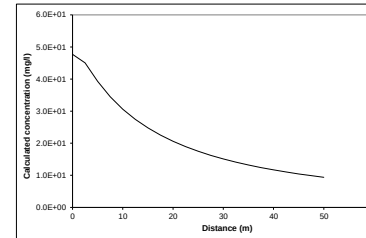
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	2.51E+03	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	2.01E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.8E+01
2.5	4.50E+01
5.0	3.93E+01
7.5	3.45E+01
10.0	3.06E+01
12.5	2.74E+01
15.0	2.48E+01
17.5	2.25E+01
20.0	2.06E+01
22.5	1.89E+01
25.0	1.75E+01
27.5	1.62E+01
30.0	1.51E+01
32.5	1.41E+01
35.0	1.32E+01
37.5	1.24E+01
40.0	1.17E+01
42.5	1.10E+01
45.0	1.04E+01
47.5	9.89E+00
50.0	9.39E+00

Remedial Targets

Remedial Target	4.57E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	9.39E+00	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Benzo (a) pyrene		
Target Concentration (C_T)	0.00017	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T Benzo (a) pyrene
0.00017 mg/l

Input Parameters

Standard entry

Variable	Value	Unit
Water filled soil porosity θ_w	1.50E-01	fraction
Air filled soil porosity θ_a	1.50E-01	fraction
Bulk density of soil zone material ρ	2.14E+01	g/cm ³
Henry's Law constant H	5.00E-05	dimensionless

Source of parameter value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f _{oc}	8.00E-03	fraction
Organic carbon partition coefficient K _{oc}	1.29E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species K _{oc,n}		l/kg
Sorption coefficient for ionised species K _{oc,i}		l/kg
pH value pH		pH units
Acid dissociation constant pK _a		
Fraction of organic carbon (in soil) f _{oc}		fraction

Soil water partition coefficient used in Level Assessment K_d 1.03E+03 l/kg Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	1.75E-01	mg/kg	(for comparison with soil analyses)
	or		
	0.00017	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Benzo (a) pyrene
0.00017

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

2.41E-02

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

2.49E+01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	Benzo (a) pyrene		from Level 1
Target Concentration	0.00017	mg/l	from Level 1
Dilution Factor	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9710	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	5.53E+00	mg/l	For comparison with measured pore water concentration.
Ogata Banks			This assumes Level 1 Remedial Target is based on Target Concentration.
	5.70E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	4.36E-03	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.29E+05 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.03E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

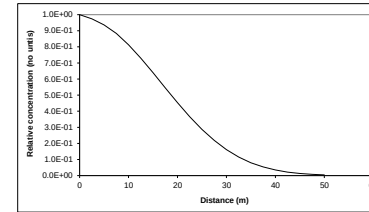
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.64E-02
2.5	9.74E-01	6.47E-02
5.0	9.37E-01	6.22E-02
7.5	8.83E-01	5.86E-02
10.0	8.13E-01	5.40E-02
12.5	7.30E-01	4.85E-02
15.0	6.39E-01	4.25E-02
17.5	5.45E-01	3.62E-02
20.0	4.53E-01	3.01E-02
22.5	3.66E-01	2.43E-02
25.0	2.87E-01	1.91E-02
27.5	2.19E-01	1.45E-02
30.0	1.61E-01	1.07E-02
32.5	1.16E-01	7.67E-03
35.0	8.00E-02	5.31E-03
37.5	5.37E-02	3.56E-03
40.0	3.48E-02	2.31E-03
42.5	2.18E-02	1.45E-03
45.0	1.32E-02	8.76E-04
47.5	7.72E-03	5.13E-04
50.0	4.36E-03	2.89E-04

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Benzo (a) pyrene	from Level 1
Target Concentration	1.70E-04	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.22E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	5.30E+02	days	
Calculated decay rate	λ	1.31E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.03E+03	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	7.36E+03	fraction
Decay rate used	λ	1.78E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	1.61E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	9.80E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.31E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

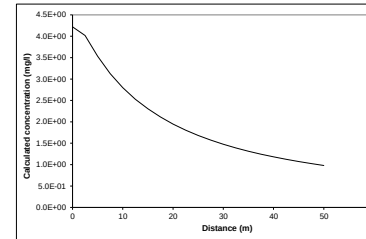
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.29E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc, n}		l/kg
Sorption coefficient for ionised species	K _{oc, i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.03E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.2E+00
2.5	4.02E+00
5.0	3.53E+00
7.5	3.13E+00
10.0	2.80E+00
12.5	2.53E+00
15.0	2.30E+00
17.5	2.11E+00
20.0	1.95E+00
22.5	1.81E+00
25.0	1.68E+00
27.5	1.57E+00
30.0	1.48E+00
32.5	1.39E+00
35.0	1.31E+00
37.5	1.24E+00
40.0	1.18E+00
42.5	1.12E+00
45.0	1.07E+00
47.5	1.02E+00
50.0	9.80E-01

Remedial Targets

Remedial Target	7.32E-04	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	9.80E-01	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C 21-C35 (Fluoranthene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C 21-C35 (Fluoranthene)

0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

7.00E-04

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

1.26E+05

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

1.01E+03

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

9.07E+01

mg/kg

(for comparison with soil analyses)

or

0.09

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C 21-C35 (Fluorant)
0.09 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Variable

Value

Unit

Source of parameter value

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.28E+01
or
1.29E+04

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C 21-C35 (Fluoranthene)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	101000	mg/kg	
Enter soil concentration	4.40E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.47E+03	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.49E+06	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	5.17E-03	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.26E+05 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.01E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity ax

Transverse dispersivity ay

Vertical dispersivity ay

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

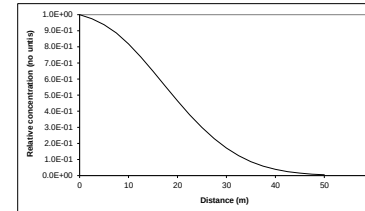
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	7.07E-01
2.5	9.75E-01	6.89E-01
5.0	9.38E-01	6.63E-01
7.5	8.86E-01	6.26E-01
10.0	8.18E-01	5.78E-01
12.5	7.37E-01	5.21E-01
15.0	6.48E-01	4.58E-01
17.5	5.56E-01	3.93E-01
20.0	4.64E-01	3.28E-01
22.5	3.78E-01	2.67E-01
25.0	2.99E-01	2.11E-01
27.5	2.30E-01	1.62E-01
30.0	1.71E-01	1.21E-01
32.5	1.24E-01	8.75E-02
35.0	8.68E-02	6.13E-02
37.5	5.89E-02	4.16E-02
40.0	3.87E-02	2.74E-02
42.5	2.46E-02	1.74E-02
45.0	1.51E-02	1.07E-02
47.5	9.00E-03	6.36E-03
50.0	5.17E-03	3.65E-03

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C 21-C35 (Fluoranth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	9.89E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	4.40E+02	days	
Calculated decay rate	λ	1.58E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.01E+03	l/kg	see options
Longitudinal dispersivity	αx	5.00E+00	m	see options
Transverse dispersivity	αz	5.00E-01	m	see options
Vertical dispersivity	αy	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	7.19E+03	fraction
Decay rate used	λ	2.19E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	1.65E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	2.27E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.35E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

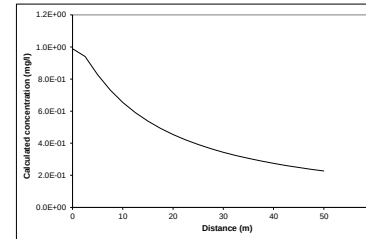
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.26E+05	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	1.01E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	5.00E+00	2.98E+00	m
Vertical dispersivity	ay	0.00E+00	5.00E-01	2.98E-01	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke

Remedial Targets

Remedial Target	3.92E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	2.27E-01	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	9.9E-01
2.5	9.41E-01
5.0	8.27E-01
7.5	7.32E-01
10.0	6.55E-01
12.5	5.91E-01
15.0	5.38E-01
17.5	4.93E-01
20.0	4.54E-01
22.5	4.21E-01
25.0	3.92E-01
27.5	3.66E-01
30.0	3.44E-01
32.5	3.24E-01
35.0	3.06E-01
37.5	2.89E-01
40.0	2.74E-01
42.5	2.61E-01
45.0	2.49E-01
47.5	2.38E-01
50.0	2.27E-01



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C12-C16 (Acenaphthylene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C12-C16 (Acenaphth

0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E-02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+03

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+01

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

3.61E+00

mg/kg

(for comparison with soil analyses)

or

0.09

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C12-C16 (Acenaph)** from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry	Infiltration	Inf	1.77E-04	m/d
	Area of contaminant source	A	5.00E+03	m ²
Entry for groundwater flow below site	Length of contaminant source in direction of groundwater flow	L	1.00E+02	m
	Saturated aquifer thickness	da	7.00E+00	m
	Hydraulic Conductivity of aquifer in which dilution occurs	K	4.45E+00	m/d
	Hydraulic gradient of water table	i	8.00E-02	fraction
	Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m
	Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m
	Calculated mixing zone thickness	Mz	7.00E+00	m

Not used in calculation

Not used in calculation

Calculated Parameters

Dilution Factor	DF	1.42E+02	
Level 2 Remedial Target		1.28E+01	mg/l
		or	
		5.12E+02	mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) C_c 0.00E+00 mg/l

Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C12-C15 (Acenaph)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	91700	mg/kg	
Enter soil concentration	6.00E+01	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.85E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.14E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	4.47E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 0.00E+00 fractionOrganic carbon partition coefficient K_{oc} 0.00E+00 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 0.00E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

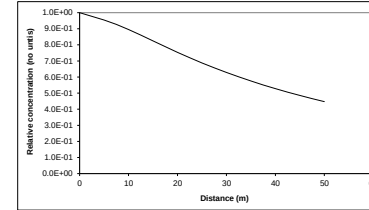
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	1.61E+01
2.5	9.77E-01	1.58E+01
5.0	9.54E-01	1.54E+01
7.5	9.27E-01	1.50E+01
10.0	8.96E-01	1.44E+01
12.5	8.61E-01	1.39E+01
15.0	8.25E-01	1.33E+01
17.5	7.89E-01	1.27E+01
20.0	7.54E-01	1.22E+01
22.5	7.20E-01	1.16E+01
25.0	6.88E-01	1.11E+01
27.5	6.57E-01	1.06E+01
30.0	6.28E-01	1.01E+01
32.5	6.01E-01	9.70E+00
35.0	5.75E-01	9.28E+00
37.5	5.51E-01	8.89E+00
40.0	5.28E-01	8.52E+00
42.5	5.06E-01	8.17E+00
45.0	4.85E-01	7.83E+00
47.5	4.66E-01	7.52E+00
50.0	4.47E-01	7.22E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C12-C16 (Acenaphth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	6.41E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	6.00E+01	days	
Calculated decay rate	λ	1.16E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	0.00E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	1.16E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	1.19E+00	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	9.89E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	6.48E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

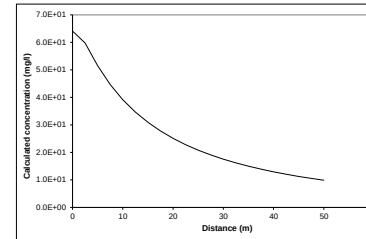
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	0.00E+00	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc, n}		l/kg
Sorption coefficient for ionised species	K _{oc, i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	α _z				m
Vertical dispersivity	α _y				
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} , α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration

	mg/l
0	6.4E+01
2.5	5.98E+01
5.0	5.15E+01
7.5	4.47E+01
10.0	3.92E+01
12.5	3.47E+01
15.0	3.09E+01
17.5	2.78E+01
20.0	2.51E+01
22.5	2.28E+01
25.0	2.08E+01
27.5	1.91E+01
30.0	1.75E+01
32.5	1.62E+01
35.0	1.50E+01
37.5	1.39E+01
40.0	1.29E+01
42.5	1.21E+01
45.0	1.13E+01
47.5	1.05E+01
50.0	9.89E+00

Remedial Targets

Remedial Target	5.84E-01	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m
Concentration of contaminant at compliance point after	C _{1D} /C ₀	9.89E+00 mg/l
		1.0E+06 days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C16-C21 (Phenanthrene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C16-C21 (Phenanthrene)
0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

1.30E-02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

1.58E+04

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

1.26E+02

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

1.14E+01

mg/kg

(for comparison with soil analyses)

or

0.09

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C16-C21 (Phenanthrene) from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters	Variable	Value	Unit	Source of parameter value
Infiltration	Inf	1.77E-04	m/d	
Area of contaminant source	A	5.00E+03	m ²	Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	
Saturated aquifer thickness	da	7.00E+00	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	4.45E+00	m/d	
Hydraulic gradient of water table	i	8.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	7.00E+00	m	

Calculated Parameters

Dilution Factor	DF	1.42E+02		
Level 2 Remedial Target		1.28E+01 or 1.61E+03	mg/l mg/kg	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C16-C21 (Phenanthrene)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	105000	mg/kg	
Enter soil concentration	2.00E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.08E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.63E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.13E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.58E+04 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.26E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

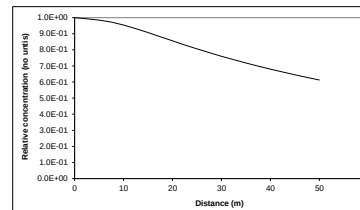
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.86E+00
2.5	9.93E-01	5.82E+00
5.0	9.85E-01	5.77E+00
7.5	9.73E-01	5.70E+00
10.0	9.55E-01	5.59E+00
12.5	9.32E-01	5.46E+00
15.0	9.07E-01	5.32E+00
17.5	8.82E-01	5.17E+00
20.0	8.56E-01	5.01E+00
22.5	8.31E-01	4.87E+00
25.0	8.06E-01	4.72E+00
27.5	7.83E-01	4.59E+00
30.0	7.60E-01	4.46E+00
32.5	7.39E-01	4.33E+00
35.0	7.19E-01	4.21E+00
37.5	6.99E-01	4.09E+00
40.0	6.80E-01	3.99E+00
42.5	6.62E-01	3.88E+00
45.0	6.45E-01	3.78E+00
47.5	6.29E-01	3.68E+00
50.0	6.13E-01	3.59E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C16-C21 (Phenanth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.90E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	2.00E+02	days	
Calculated decay rate	λ	3.47E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	
Parameters values determined from options				
Partition coefficient	Kd	1.26E+02	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	9.03E+02	fraction
Decay rate used	λ	3.84E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	1.31E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.04E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.70E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

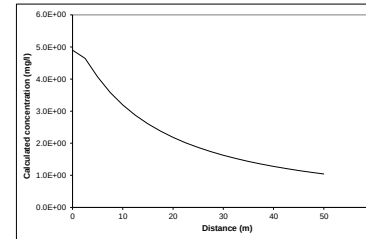
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.58E+04	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	1.26E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	4.9E+00
2.5	4.64E+00
5.0	4.07E+00
7.5	3.58E+00
10.0	3.19E+00
12.5	2.87E+00
15.0	2.60E+00
17.5	2.38E+00
20.0	2.18E+00
22.5	2.01E+00
25.0	1.87E+00
27.5	1.74E+00
30.0	1.63E+00
32.5	1.52E+00
35.0	1.43E+00
37.5	1.35E+00
40.0	1.28E+00
42.5	1.21E+00
45.0	1.15E+00
47.5	1.09E+00
50.0	1.04E+00

Remedial Targets

Remedial Target	4.23E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.04E+00	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C8-C10 (Xylene)		
Target Concentration (C_T)	0.5	mg/l	Origin of C_T: DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C8-C10 (Xylene)
0.5 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 2.90E-01 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 1.59E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pK_a
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 1.27E+01 l/kg Calculated value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	6.36E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.5	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C8-C10 (Xylene)
0.5

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

7.09E+01
or
9.02E+02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C8-C10 (Xylene)		from Level 1
Target Concentration	C _T	0.5	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	7170	mg/kg	
Enter soil concentration	1.80E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.17E+02	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.49E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.06E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.59E+03 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.27E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

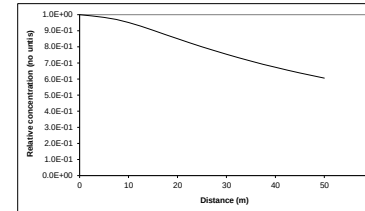
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.97E+00
2.5	9.92E-01	3.94E+00
5.0	9.83E-01	3.91E+00
7.5	9.70E-01	3.86E+00
10.0	9.52E-01	3.78E+00
12.5	9.29E-01	3.68E+00
15.0	9.03E-01	3.59E+00
17.5	8.77E-01	3.48E+00
20.0	8.51E-01	3.38E+00
22.5	8.25E-01	3.28E+00
25.0	8.00E-01	3.18E+00
27.5	7.77E-01	3.08E+00
30.0	7.54E-01	2.99E+00
32.5	7.32E-01	2.91E+00
35.0	7.11E-01	2.83E+00
37.5	6.92E-01	2.75E+00
40.0	6.73E-01	2.67E+00
42.5	6.55E-01	2.60E+00
45.0	6.38E-01	2.53E+00
47.5	6.21E-01	2.47E+00
50.0	6.06E-01	2.41E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Linedside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C8-C10 (Xylene)		from Level 1
Target Concentration	C _T	5.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	7.10E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	1.27E+01	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	9.17E+01	fraction
Decay rate used	λ	4.20E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	1.29E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.49E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.78E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

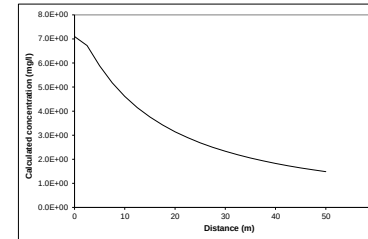
Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer	foc		
Organic carbon partition coefficient	Koc	1.59E+03	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	1.27E+01	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.414}; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	7.1E+00
2.5	6.72E+00
5.0	5.88E+00
7.5	5.18E+00
10.0	4.61E+00
12.5	4.15E+00
15.0	3.76E+00
17.5	3.43E+00
20.0	3.14E+00
22.5	2.90E+00
25.0	2.69E+00
27.5	2.50E+00
30.0	2.33E+00
32.5	2.19E+00
35.0	2.05E+00
37.5	1.94E+00
40.0	1.83E+00
42.5	1.73E+00
45.0	1.64E+00
47.5	1.56E+00
50.0	1.49E+00

Remedial Targets

Remedial Target	2.39E+00	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after 1.49E+00 mg/l
1.0E+06 days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C7-C8 (Toluene)		
Target Concentration (C_T)	0.074	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C7-C8 (Toluene)

0.074 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

2.72E-01

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

2.51E+02

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.01E+00

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

1.49E-01

mg/kg

(for comparison with soil analyses)

or

0.074

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C7-C8 (Toluene)
0.074

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Infiltration
Area of contaminant source

Variable

Inf
A

Value

1.77E-04
5.00E+03

Unit

m/d
m²

Source of parameter value

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.05E+01
or
2.12E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Contaminant	Variable	Value	Unit	Source
Aromatic C7-C8 (Toluene)				from Level 1
Target Concentration	C _T	0.074	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	185	mg/kg	
Enter soil concentration	1.40E+01	days	
Half life for degradation of contaminant in water	1.40E+01	days	
Calculated decay rate	4.95E-02	days ⁻¹	calculated
Width of plume in aquifer at source	1.50E+01	m	from Level 2
Plume thickness in aquifer at source	7.00E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+01	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	8.06E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.45E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+06	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	2.01E+00	l/kg see options
Longitudinal dispersivity	ax	5.000	m see options
Transverse dispersivity	az	0.500	m see options
Vertical dispersivity	ay	0.050	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	1.20E+00	m/d
Retardation factor	1.44E+02	fraction
Decay rate used	3.43E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	8.06E-02	fraction
Rate of contaminant flow due to retardation	8.29E-03	m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	fraction
Attenuation factor (C _{CP} /C ₀)	AF	8.20E+00
Calculated soil leachate concentration	Co	9.17E+01

Remedial Targets

Level 3 Remedial Target	8.60E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.73E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	1.22E-01	fraction Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+02 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity ax

Transverse dispersivity az

Vertical dispersivity ay

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

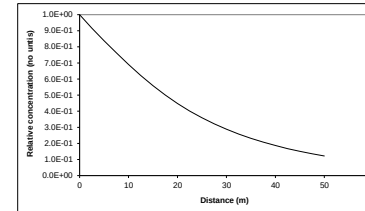
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.47E-01
2.5	9.16E-01	5.92E-01
5.0	8.38E-01	5.42E-01
7.5	7.63E-01	4.94E-01
10.0	6.91E-01	4.47E-01
12.5	6.22E-01	4.02E-01
15.0	5.58E-01	3.61E-01
17.5	5.00E-01	3.24E-01
20.0	4.48E-01	2.90E-01
22.5	4.01E-01	2.60E-01
25.0	3.59E-01	2.32E-01
27.5	3.22E-01	2.08E-01
30.0	2.88E-01	1.86E-01
32.5	2.58E-01	1.67E-01
35.0	2.32E-01	1.50E-01
37.5	2.08E-01	1.35E-01
40.0	1.87E-01	1.21E-01
42.5	1.68E-01	1.09E-01
45.0	1.51E-01	9.75E-02
47.5	1.36E-01	8.77E-02
50.0	1.22E-01	7.89E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C7-C8 (Toluene)	from Level 1
Target Concentration	C _T	7.40E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.80E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.40E+01	days	
Calculated decay rate	λ	4.95E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	2.01E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.53E+01	fraction
Decay rate used	λ	3.23E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	7.74E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	7.51E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.40E+01	

Select Method for deriving Partition Co-efficient (using pull down menu)

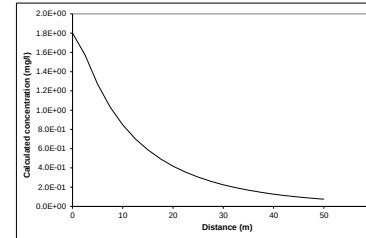
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	8.00E-03 fraction
Organic carbon partition coefficient	Koc	2.51E+02 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	l/kg
Sorption coefficient for ionised species	K _{oc, i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	2.01E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} , α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.8E+00
2.5	1.57E+00
5.0	1.27E+00
7.5	1.03E+00
10.0	8.47E-01
12.5	7.02E-01
15.0	5.87E-01
17.5	4.94E-01
20.0	4.18E-01
22.5	3.56E-01
25.0	3.04E-01
27.5	2.61E-01
30.0	2.25E-01
32.5	1.94E-01
35.0	1.68E-01
37.5	1.46E-01
40.0	1.28E-01
42.5	1.11E-01
45.0	9.76E-02
47.5	8.55E-02
50.0	7.51E-02

Remedial Targets

Remedial Target	1.77E+00	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	7.51E-02	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aromatic C5-C7 (Benzene)		
Target Concentration (C_T)	0.01	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C5-C7 (Benzene)
0.01 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E+02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+06

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+04

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

4.01E+02

mg/kg

(for comparison with soil analyses)

or

0.01

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C5-C7 (Benzene)
0.01

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

1.42E+00

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

5.68E+04

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C5-C7 (Benzene)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	950	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 4.01E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

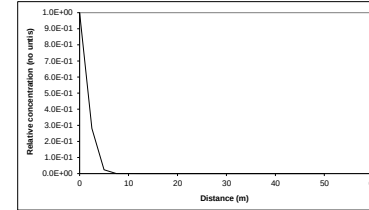
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	1.67E-04
2.5	2.81E-01	4.69E-05
5.0	2.34E-02	3.91E-06
7.5	5.04E-04	8.42E-08
10.0	2.62E-06	4.38E-10
12.5	0.00E+00	0.00E+00
15.0	0.00E+00	0.00E+00
17.5	0.00E+00	0.00E+00
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C5-C7 (Benzene)		from Level 1
Target Concentration	C _T	1.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	8.65E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	4.01E+04	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	2.86E+05	fraction
Decay rate used	λ	1.35E-08	d ⁻¹
Rate of contaminant flow due to retardation	u	4.15E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	0.00E+00	mg/l

Attenuation factor (one way vertical dispersion, COICED) AF breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	8.00E-03 fraction
Organic carbon partition coefficient	Koc	5.01E+06 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	l/kg
Sorption coefficient for ionised species	K _{oc, i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	4.01E+04 l/kg

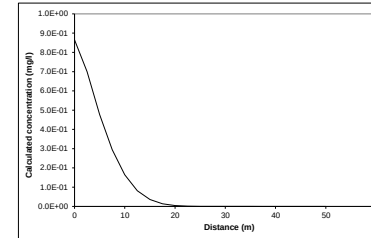
Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	m

Note values of dispersivity must be > 0

For calculated value, assumes α_x = 0.1 * x, α_z = 0.01 * x, α_y = 0.001 * x
Xu & Eckstein (1995) report α_x = 0.83(log₁₀x)^{-0.414}; α_z = α_x/10, α_y = α_x/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
0	8.7E-01
2.5	6.99E-01
5.0	4.77E-01
7.5	2.95E-01
10.0	1.64E-01
12.5	8.16E-02
15.0	3.60E-02
17.5	1.40E-02
20.0	4.76E-03
22.5	1.42E-03
25.0	3.69E-04
27.5	8.36E-05
30.0	1.65E-05
32.5	1.58E-06
35.0	2.33E-07
37.5	2.98E-08
40.0	3.29E-09
42.5	0.00E+00
45.0	0.00E+00
47.5	0.00E+00
50.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
-----------------	-----------	------	---

Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after	C _{1D} /C ₀	0.00E+00	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aliphatic C12-C16		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aliphatic C12-C16

0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E+02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+06

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+04

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.00E+03

mg/kg

(for comparison with soil analyses)

or

0.05

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aliphatic C12-C16
0.05

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

7.09E+00
or
2.84E+05

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic C12-C16		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	950	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 5.01E+06 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 4.01E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

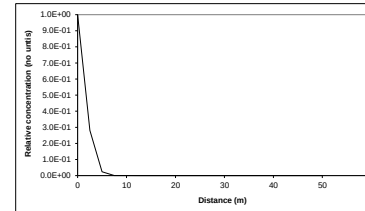
Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.67E-04
2.5	2.81E-01	4.69E-05
5.0	2.34E-02	3.91E-06
7.5	5.04E-04	8.42E-08
10.0	2.62E-06	4.38E-10
12.5	0.00E+00	0.00E+00
15.0	0.00E+00	0.00E+00
17.5	0.00E+00	0.00E+00
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aliphatic C12-C18		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	8.65E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	4.01E+04	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	2.86E+05	fraction
Decay rate used	λ	1.35E-08	d ⁻¹
Rate of contaminant flow due to retardation	u	4.15E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	0.00E+00	mg/l

Attenuation factor (one way vertical dispersion, COICED) AF breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

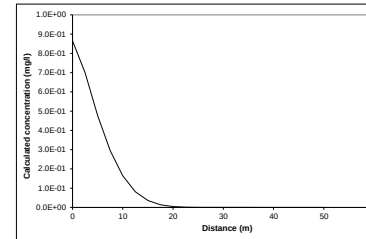
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	5.01E+06	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.01E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.7E-01
2.5	6.99E-01
5.0	4.77E-01
7.5	2.95E-01
10.0	1.64E-01
12.5	8.16E-02
15.0	3.60E-02
17.5	1.40E-02
20.0	4.76E-03
22.5	1.42E-03
25.0	3.69E-04
27.5	8.36E-05
30.0	1.65E-05
32.5	1.58E-06
35.0	2.33E-07
37.5	2.98E-08
40.0	3.29E-09
42.5	0.00E+00
45.0	0.00E+00
47.5	0.00E+00
50.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
-----------------	-----------	------	---

Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after C_{1D}/C₀ 0.00E+00 mg/l
1.0E+06 days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Limeside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Aliphatic C10-C12		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T 0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 1.30E+02 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction

Organic carbon partition coefficient K_{oc} 2.51E+05 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species K_{oc,n} l/kg

Sorption coefficient for ionised species K_{oc,i} l/kg

pH value pH pH units

Acid dissociation constant pK_a

Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 2.01E+03 l/kg Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	1.00E+02	mg/kg	(for comparison with soil analyses)
	or		
	0.05	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aliphatic C10-C12
0.05

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

7.09E+00
or
1.42E+04

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic C10-C12		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	711	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	4.00E+06	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	8.03E+09	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.77E-06	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+05 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

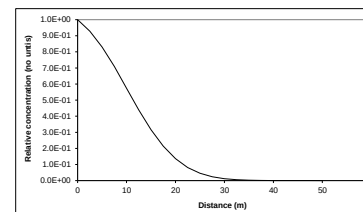
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	2.50E-03
2.5	9.28E-01	2.32E-03
5.0	8.31E-01	2.07E-03
7.5	7.10E-01	1.77E-03
10.0	5.74E-01	1.43E-03
12.5	4.39E-01	1.09E-03
15.0	3.16E-01	7.88E-04
17.5	2.14E-01	5.34E-04
20.0	1.36E-01	3.40E-04
22.5	8.12E-02	2.03E-04
25.0	4.54E-02	1.13E-04
27.5	2.37E-02	5.92E-05
30.0	1.16E-02	2.89E-05
32.5	5.29E-03	1.32E-05
35.0	2.25E-03	5.62E-06
37.5	8.94E-04	2.23E-06
40.0	3.31E-04	8.26E-07
42.5	1.14E-04	2.85E-07
45.0	2.16E-05	5.39E-08
47.5	6.41E-06	1.60E-08
50.0	1.77E-06	4.43E-09

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Llineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aliphatic C10-C12	from Level 1
Target Concentration	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	3.52E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.01E+03	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	1.43E+04	fraction
Decay rate used	λ	2.69E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	8.28E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	6.85E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	5.14E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

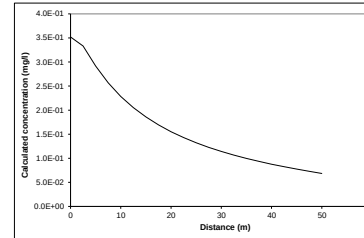
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	2.51E+05	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	2.01E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Lineside Dyke

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	3.5E-01
2.5	3.33E-01
5.0	2.92E-01
7.5	2.57E-01
10.0	2.28E-01
12.5	2.05E-01
15.0	1.86E-01
17.5	1.69E-01
20.0	1.55E-01
22.5	1.43E-01
25.0	1.32E-01
27.5	1.23E-01
30.0	1.14E-01
32.5	1.07E-01
35.0	9.98E-02
37.5	9.35E-02
40.0	8.78E-02
42.5	8.24E-02
45.0	7.75E-02
47.5	7.28E-02
50.0	6.85E-02

Remedial Targets

Remedial Target	2.57E-01	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	6.85E-02	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Thiocyanate		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : Surf Water

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant
Target concentration

C_T

Thiocyanate
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

fraction

Organic carbon partition coefficient

K_{oc}

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

9.90E+00 l/kg

Specified value

Level 1 Remedial Target

Level 1 Remedial Target

4.95E-01 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T Thiocyanate
0.05 mg/l from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Infiltration
Area of contaminant source

Variable

Inf
A

Value

1.77E-04
5.00E+03

Unit

m/d
m²

Source of parameter value

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

1.42E+02

Level 2 Remedial Target

7.09E+00
or
7.02E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

Cc

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Thiocyanate		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9	mg/kg	
Enter soil concentration	1.00E+03	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.03E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.02E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.90E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	9.90E+00	l/kg
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Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
---------------------------------------	-----	--	----------

Organic carbon partition coefficient	Koc		l/kg
--------------------------------------	-----	--	------

Sorption coefficient for related species	K _{oc,li}		l/kg
--	--------------------	--	------

Sorption coefficient for ionised species	K _{oc,i}		l/kg
--	-------------------	--	------

pH value	pH		
----------	----	--	--

Acid dissociation constant	pKa		
----------------------------	-----	--	--

Fraction of organic carbon in aquifer	foc		fraction
---------------------------------------	-----	--	----------

Soil water partition coefficient	Kd	9.90E+00	l/kg
----------------------------------	----	----------	------

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

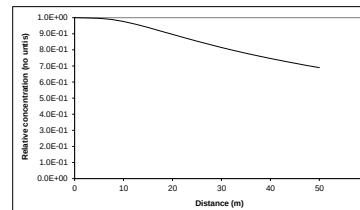
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	5.00E+00
Transverse dispersivity	az	0.00E+00	5.00E-01
Vertical dispersivity	ay	0.00E+00	5.00E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	6.41E-03
2.5	9.99E-01	6.40E-03
5.0	9.96E-01	6.38E-03
7.5	9.90E-01	6.34E-03
10.0	9.77E-01	6.26E-03
12.5	9.59E-01	6.15E-03
15.0	9.39E-01	6.02E-03
17.5	9.18E-01	5.88E-03
20.0	8.96E-01	5.74E-03
22.5	8.75E-01	5.60E-03
25.0	8.54E-01	5.47E-03
27.5	8.34E-01	5.34E-03
30.0	8.15E-01	5.22E-03
32.5	7.96E-01	5.10E-03
35.0	7.79E-01	4.99E-03
37.5	7.62E-01	4.88E-03
40.0	7.46E-01	4.78E-03
42.5	7.31E-01	4.69E-03
45.0	7.17E-01	4.59E-03
47.5	7.03E-01	4.50E-03
50.0	6.90E-01	4.42E-03

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Thiocyanate	from Level 1
Target Concentration	C _T 5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.50E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days	
Calculated decay rate	λ	6.93E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	7.16E+01	fraction
Decay rate used	λ	9.68E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	1.66E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	5.96E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.19E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

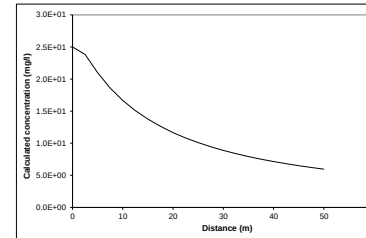
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	Koc		l/kg
Organic carbon partition coefficient	K _{oc}		l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,ion}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	9.90E+00	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	2.5E+01
2.5	2.38E+01
5.0	2.10E+01
7.5	1.86E+01
10.0	1.67E+01
12.5	1.51E+01
15.0	1.38E+01
17.5	1.26E+01
20.0	1.17E+01
22.5	1.08E+01
25.0	1.01E+01
27.5	9.45E+00
30.0	8.89E+00
32.5	8.38E+00
35.0	7.93E+00
37.5	7.52E+00
40.0	7.15E+00
42.5	6.81E+00
45.0	6.50E+00
47.5	6.22E+00
50.0	5.96E+00

Remedial Targets

Remedial Target	2.10E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after C_{1D}/C₀ 5.96E+00 mg/l
1.0E+06 days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Linesside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Lineside Dyke
Contaminant	Cyanide (total)		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : Surf Water

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant
Target concentration
 C_T

Cyanide (total)
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) foc
Organic carbon partition coefficient Koc

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) foc fraction

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment Kd 9.90E+00 l/kg Specified value

Level 1 Remedial Target

Level 1 Remedial Target	4.95E-01	mg/kg	(for comparison with soil analyses)
	or		
	0.05	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Lineside Dyke

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Cyanide (total)
0.05

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
4.45E+00
8.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor DF

1.42E+02

Level 2 Remedial Target

7.09E+00
or
7.02E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Lineside Dyke

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Cyanide (total)		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.42E+02		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	7800	mg/kg	
Enter soil concentration	1.00E+03	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.03E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.02E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.90E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,rel} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 9.90E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

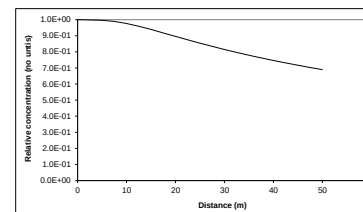
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.55E+00
2.5	9.99E-01	5.54E+00
5.0	9.96E-01	5.53E+00
7.5	9.90E-01	5.49E+00
10.0	9.77E-01	5.42E+00
12.5	9.59E-01	5.33E+00
15.0	9.39E-01	5.21E+00
17.5	9.18E-01	5.10E+00
20.0	8.96E-01	4.98E+00
22.5	8.75E-01	4.86E+00
25.0	8.54E-01	4.74E+00
27.5	8.34E-01	4.63E+00
30.0	8.15E-01	4.52E+00
32.5	7.96E-01	4.42E+00
35.0	7.79E-01	4.33E+00
37.5	7.62E-01	4.23E+00
40.0	7.46E-01	4.15E+00
42.5	7.31E-01	4.06E+00
45.0	7.17E-01	3.98E+00
47.5	7.03E-01	3.90E+00
50.0	6.90E-01	3.83E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Lineside Dyke

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	C _T	Cyanide (total)	mg/l	from Level 1
Target Concentration	C _T	5.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.34E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days	
Calculated decay rate	λ	6.93E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	8.00E-02	fraction	
Hydraulic conductivity of aquifer	K	4.45E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.19E+00	m/d
Retardation factor	Rf	7.16E+01	fraction
Decay rate used	λ	9.68E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	1.66E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.03E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.19E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

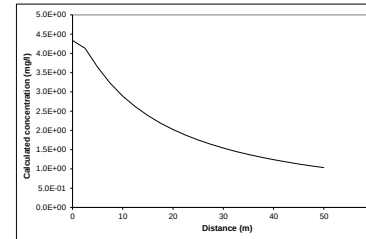
User specified value for partition coefficient
--

Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	foc		
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	9.90E+00	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length
--

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	Concentration
Distance	Concentration

0	4.34E+00
2.5	4.13E+00
5.0	3.64E+00
7.5	3.22E+00
10.0	2.89E+00
12.5	2.61E+00
15.0	2.38E+00
17.5	2.19E+00
20.0	2.02E+00
22.5	1.88E+00
25.0	1.75E+00
27.5	1.64E+00
30.0	1.54E+00
32.5	1.45E+00
35.0	1.37E+00
37.5	1.30E+00
40.0	1.24E+00
42.5	1.18E+00
45.0	1.13E+00
47.5	1.08E+00
50.0	1.03E+00

Remedial Targets

Remedial Target	2.10E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.03E+00
		1.0E+06
		days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Lineside Dyke



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	Adam Wilson		
Date:	19.7.20	Version:	Northern Plume
Contaminant	Phenol		
Target Concentration (C _T)	0.0077	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Phenol
0.0077 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+00

g/cm³

Henry's Law constant

H

1.64E-05

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

2.88E+01

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.30E-01

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.31E-03

mg/kg

(for comparison with soil analyses)

or

0.0077

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: Adam Wilson

Date: 19.7.20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T **Phenol** from Level 1
0.0077 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable Value Unit Source of parameter value

Standard entry

Infiltration	Inf	1.77E-04	m/d	
Area of contaminant source	A	5.00E+03	m ²	Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	
Saturated aquifer thickness	da	7.00E+00	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d	
Hydraulic gradient of water table	i	4.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	1.00E-08	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	7.00E+00	m	

Calculated Parameters

Dilution Factor	DF	4.21E+01	
Level 2 Remedial Target		3.24E-01 mg/l or 9.75E-02 mg/kg	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	Adam Wilson
Date:	19.7.20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Phenol		from Level 1
Target Concentration	C _T	0.0077	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	10	mg/kg	
Enter soil concentration	1.00E+01	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.11E+08	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	6.34E+08	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	300	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.54E-10	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.88E+01 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.30E-01 l/kg

Define dispersivity (click brown cell and use pull down list)

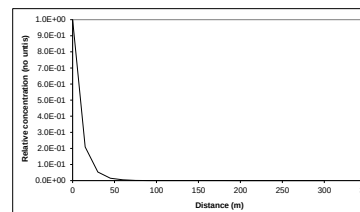
Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	3.00E+01
Transverse dispersivity	az	0.00E+00	3.00E+00
Vertical dispersivity	ay	0.00E+00	3.00E-01

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	7.90E-01
15.0	2.09E-01	1.65E-01
30.0	5.32E-02	4.20E-02
45.0	1.50E-02	1.19E-02
60.0	4.51E-03	3.57E-03
75.0	1.41E-03	1.11E-03
90.0	4.51E-04	3.56E-04
105.0	1.47E-04	1.17E-04
120.0	4.90E-05	3.87E-05
135.0	1.65E-05	1.30E-05
150.0	5.59E-06	4.41E-06
165.0	1.91E-06	1.51E-06
180.0	6.59E-07	5.21E-07
195.0	2.28E-07	1.80E-07
210.0	7.96E-08	6.29E-08
225.0	2.79E-08	2.20E-08
240.0	9.79E-09	7.73E-09
255.0	3.45E-09	2.73E-09
270.0	1.22E-09	9.64E-10
285.0	4.33E-10	3.42E-10
300.0	1.54E-10	1.22E-10

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: Adam Wilson

Date: 19.7.20

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Phenol		from Level 1
Target Concentration	C _T	7.70E-03	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.00E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+01	days	
Calculated decay rate	λ	6.93E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	3.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.30E-01	l/kg	see options
Longitudinal dispersivity	ax	3.00E+01	m	see options
Transverse dispersivity	az	3.00E+00	m	see options
Vertical dispersivity	ay	3.00E-01	m	see options

Calculated Parameters

Variable

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	2.64E+00	fraction
Decay rate used	λ	2.62E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	1.31E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.72E-10	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	5.80E+10	

Remedial Targets

Remedial Target	4.47E+08	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	300	m	
Concentration of contaminant at compliance point	C _{1D} /C ₀	1.72E-10	mg/l Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

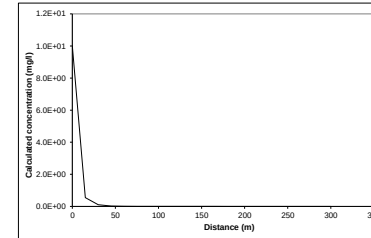
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	8.00E-03 fraction
Organic carbon partition coefficient	Koc	2.88E+01 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	
Sorption coefficient for ionised species	K _{oc, i}	
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	
Soil water partition coefficient	Kd	2.30E-01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax	3.00E+01	7.41E+00	m
Transverse dispersivity	az	3.00E+00	7.41E-01	m
Vertical dispersivity	ay	3.00E-01	7.41E-02	m
Note values of dispersivity must be > 0				
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x				
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Monckton Coking Works
Completed by:	Adam Wilson
Date:	19.7.20
Version:	Northern Plume

Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance	Concentration
	mg/l
0	1.0E+01
15.0	5.40E-01
30.0	1.07E-01
45.0	2.68E-02
60.0	7.46E-03
75.0	2.21E-03
90.0	6.80E-04
105.0	2.15E-04
120.0	6.94E-05
135.0	2.27E-05
150.0	7.53E-06
165.0	2.52E-06
180.0	8.52E-07
195.0	2.89E-07
210.0	9.90E-08
225.0	3.40E-08
240.0	1.17E-08
255.0	4.07E-09
270.0	1.41E-09
285.0	4.93E-10
300.0	1.72E-10



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson	Version:	Northern Plume
Date:	15-Jul-20		
Contaminant	Selenium		
Target Concentration (C _T)	0.01	mg/l	Origin of C _T : DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Selenium
0.01 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) foc 8.00E-03 fraction

Organic carbon partition coefficient Koc 5.00E+01 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg

Sorption coefficient for ionised species $K_{oc,i}$ l/kg

pH value pH pH units

Acid dissociation constant pKa

Fraction of organic carbon (in soil) foc fraction

Soil water partition coefficient used in Level Assessment Kd 4.00E-01 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	4.07E-03	mg/kg	(for comparison with soil analyses)
	or		
	0.01	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Selenium
0.01

from Level 1
from Level 1

mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

4.21E-01

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

1.71E-01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Selenium		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9	mg/kg	
Enter soil concentration	9	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.03E+03	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.19E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	300	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	4.09E-04	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 5.00E+01 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 5.00E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Enter value Calc value Xu & Eckstein

ax 0.00E+00 3.00E+01 7.41E+00 m

Transverse dispersivity az 0.00E+00 3.00E+00 7.41E+01 m

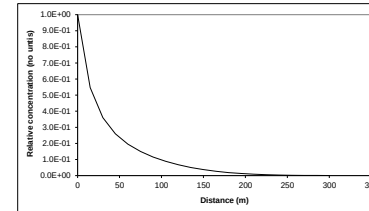
Vertical dispersivity ay 0.00E+00 3.00E-01 7.41E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.25E-01
15.0	5.47E-01	2.87E-01
30.0	3.60E-01	1.89E-01
45.0	2.60E-01	1.36E-01
60.0	1.95E-01	1.02E-01
75.0	1.50E-01	7.86E-02
90.0	1.15E-01	6.06E-02
105.0	8.86E-02	4.65E-02
120.0	6.74E-02	3.54E-02
135.0	5.05E-02	2.65E-02
150.0	3.72E-02	1.95E-02
165.0	2.68E-02	1.41E-02
180.0	1.88E-02	9.89E-03
195.0	1.29E-02	6.78E-03
210.0	8.63E-03	4.53E-03
225.0	5.60E-03	2.94E-03
240.0	3.53E-03	1.85E-03
255.0	2.16E-03	1.13E-03
270.0	1.28E-03	6.72E-04
285.0	7.35E-04	3.86E-04
300.0	4.09E-04	2.15E-04

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Selenium		from Level 1
Target Concentration	C _T	1.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.00E-02	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	3.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	5.00E+01	l/kg	see options
Longitudinal dispersivity	ax	3.00E+01	m	see options
Transverse dispersivity	az	3.00E+00	m	see options
Vertical dispersivity	ay	3.00E-01	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	3.58E+02	fraction
Decay rate used	λ	1.96E-104	days ⁻¹
Rate of contaminant flow due to retardation	u	9.69E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.67E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.20E+02	

Select Method for deriving Partition Co-efficient (using pull down menu)

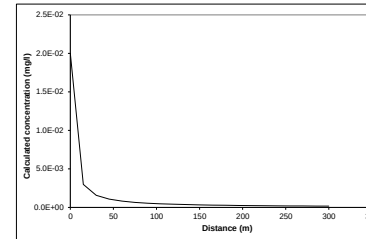
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	5.00E+01	l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.00E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	3.00E+01	7.41E+00	m
Vertical dispersivity	ay	0.00E+00	3.00E+00	7.41E-01	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume

Remedial Targets

Remedial Target	1.20E+00	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	300	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.67E-04	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.





Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Nickel		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Nickel
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

5.00E+02 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.00E+00 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.00E-01 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T **Nickel** from Level 1
0.05 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable Value Unit Source of parameter value

Standard entry

Infiltration	Inf	1.77E-04	m/d	
Area of contaminant source	A	5.00E+03	m ²	Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	
Saturated aquifer thickness	da	7.00E+00	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d	
Hydraulic gradient of water table	i	4.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	7.00E+00	m	

Calculated Parameters

Dilution Factor	DF	4.21E+01	
Level 2 Remedial Target		2.11E+00 mg/l or 8.44E+00 mg/kg	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Nickel		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	198	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days
Calculated decay rate	λ	7.00E-102	days ⁻¹
Width of plume in aquifer at source	Sz	1.50E+01	m
Plume thickness in aquifer at source	Sy	7.00E+00	m
Bulk density of aquifer materials	ρ	2.14E+01	g/cm ³
Effective porosity of aquifer	n	3.00E-01	fraction
Hydraulic gradient	i	4.10E-02	fraction
Hydraulic conductivity of saturated aquifer	K	2.60E+00	m/d
Distance to compliance point	x	3.00E+02	m
Distance (lateral) to compliance point perpendicular to flow direction	z		m
Distance (depth) to compliance point perpendicular to flow direction	y		m
Time since pollutant entered groundwater	t	1.00E+06	days
time variant options only			
Parameters values determined from options			
Partition coefficient	Kd	5.00E+02	l/kg
Longitudinal dispersivity	ax	30.000	m
Transverse dispersivity	az	3.000	m
Vertical dispersivity	ay	0.300	m

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	3.55E-01 m/d
Retardation factor	Rf	3.57E+04
Decay rate used	λ	1.96E-106 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.10E-02
Rate of contaminant flow due to retardation	u	9.96E-06 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00
Attenuation factor (C ₀ /C ₁₀₀)	AF	breakthrough at or
Calculated soil leachate concentration	Co	4.94E+01 mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	300	m	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc}Organic carbon partition coefficient K_{oc}Sorption coefficient for related species K_{oc,rel}Sorption coefficient for ionised species K_{oc,li}

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc}

Soil water partition coefficient Kd 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

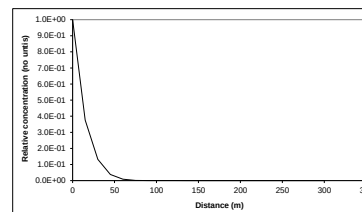
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	3.00E+01
Transverse dispersivity	az	0.00E+00	3.00E+00
Vertical dispersivity	ay	0.00E+00	3.00E-01

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀t)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.17E+00
15.0	3.76E-01	4.41E-01
30.0	1.32E-01	1.54E-01
45.0	3.78E-02	4.44E-02
60.0	8.34E-03	9.78E-03
75.0	1.36E-03	1.59E-03
90.0	1.60E-04	1.88E-04
105.0	1.36E-05	1.59E-05
120.0	8.11E-07	9.51E-07
135.0	1.82E-08	2.14E-08
150.0	0.00E+00	0.00E+00
165.0	0.00E+00	0.00E+00
180.0	0.00E+00	0.00E+00
195.0	0.00E+00	0.00E+00
210.0	0.00E+00	0.00E+00
225.0	0.00E+00	0.00E+00
240.0	0.00E+00	0.00E+00
255.0	0.00E+00	0.00E+00
270.0	0.00E+00	0.00E+00
285.0	0.00E+00	0.00E+00
300.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Nickel		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.26E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	3.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	5.00E+02	l/kg	see options
Longitudinal dispersivity	α _x	3.00E+01	m	see options
Transverse dispersivity	α _z	3.00E+00	m	see options
Vertical dispersivity	α _y	3.00E-01	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	3.57E+03	fraction
Decay rate used	λ	1.96E-105	d ⁻¹
Rate of contaminant flow due to retardation	u	9.72E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.15E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.96E+04	

Select Method for deriving Partition Co-efficient (using pull down menu)

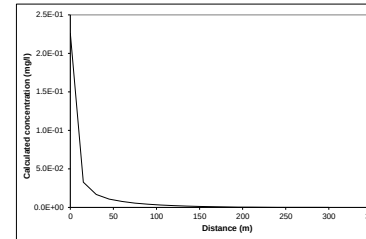
User specified value for partition coefficient

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	5.00E+02 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	0.00E+00	3.00E+01	7.41E+00 m
Transverse dispersivity	α _z	0.00E+00	3.00E+00	7.41E-01 m
Vertical dispersivity	α _y	0.00E+00	3.00E-01	7.41E-02 m
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume

Remedial Targets

Remedial Target	9.79E+02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	300	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.15E-05	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.





Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Lead		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Lead
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

1.58E+04 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

1.26E+02 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

6.32E+00 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Lead
0.05

from Level 1
from Level 1

mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

2.11E+00

mg/l

or

2.66E+02

mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	Lead		from Level 1
Target Concentration	0.05	mg/l	from Level 1
Dilution Factor	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	584	mg/kg	
Enter soil concentration	9.90E+100	days	
Half life for degradation of contaminant in water	7.00E-102	days ⁻¹	calculated
Width of plume in aquifer at source	1.50E+01	m	from Level 2
Plume thickness in aquifer at source	7.00E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+01	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	4.10E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	2.60E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+06	days	time variant options only
Parameters values determined from options			
Partition coefficient	1.58E+04	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	3.55E-01	m/d
Retardation factor	1.13E+06	fraction
Decay rate used	6.21E-108	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	4.10E-02	fraction
Rate of contaminant flow due to retardation	3.15E-07	m/d
Ratio of Compliance Point to Source Concentration	0.00E+00	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	4.62E+00	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	partitioning equation.
		fraction	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	1.58E+04	l/kg
----------------------------------	----	----------	------

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	K _{oc,ij}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

Soil water partition coefficient	Kd	1.58E+04	l/kg
----------------------------------	----	----------	------

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

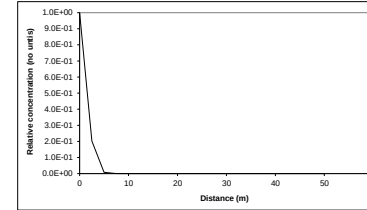
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	5.00E+00
Transverse dispersivity	az	0.00E+00	5.00E-01
Vertical dispersivity	ay	0.00E+00	5.00E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	1.10E-01
2.5	2.02E-01	2.22E-02
5.0	7.88E-03	8.65E-04
7.5	4.95E-05	5.43E-06
10.0	2.39E-08	2.62E-09
12.5	0.00E+00	0.00E+00
15.0	0.00E+00	0.00E+00
17.5	0.00E+00	0.00E+00
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Lead		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	7.00E-03	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	1.58E+04	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.13E+05	fraction
Decay rate used	λ	6.21E-107	d ⁻¹
Rate of contaminant flow due to retardation	u	3.08E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	0.00E+00	mg/l

Attenuation factor (one way vertical dispersion, CO/CED) AF breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

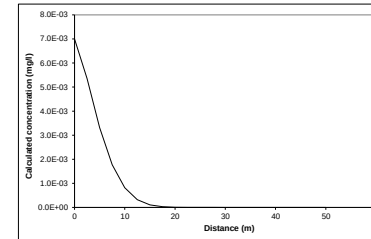
User specified value for partition coefficient

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	1.58E+04 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	fraction
acid dissociation constant	pKa	fraction
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	1.58E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	5.00E+00	2.98E+00	m
Vertical dispersivity	ay	0.00E+00	5.00E-01	2.98E-01	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	7.0E-03
2.5	5.36E-03
5.0	3.31E-03
7.5	1.77E-04
10.0	8.16E-04
12.5	3.19E-04
15.0	1.05E-04
17.5	2.89E-05
20.0	6.62E-06
22.5	1.26E-06
25.0	1.99E-07
27.5	2.59E-08
30.0	1.53E-09
32.5	1.34E-10
35.0	0.00E+00
37.5	0.00E+00
40.0	0.00E+00
42.5	0.00E+00
45.0	0.00E+00
47.5	0.00E+00
50.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
-----------------	-----------	------	---

Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after C_{1D}/C₀ 0.00E+00 mg/l
1.0E+06 days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson	Version:	Northern Plume
Date:	15-Jul-20		
Contaminant	Arsenic		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Arsenic
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03 fraction

Organic carbon partition coefficient

K_{oc}

2.51E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.01E+01 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

1.00E+00 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Arsenic
0.05

from Level 1
from Level 1

mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
8.00E-03

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor DF

3.55E+01

Level 2 Remedial Target

1.78E+00

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

3.57E+01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	3.55E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	36	mg/kg	
Enter soil concentration	9.90E+100	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	7.90E+04	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.59E+06	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	2.25E-05	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer foc fraction

Organic carbon partition coefficient Koc l/kg

Sorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer foc fraction

Soil water partition coefficient Kd 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

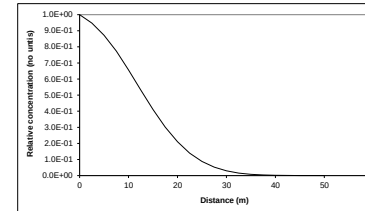
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.04E-02
2.5	9.48E-01	4.78E-02
5.0	8.72E-01	4.40E-02
7.5	7.73E-01	3.90E-02
10.0	6.56E-01	3.31E-02
12.5	5.32E-01	2.68E-02
15.0	4.10E-01	2.07E-02
17.5	3.02E-01	1.52E-02
20.0	2.11E-01	1.06E-02
22.5	1.40E-01	7.04E-03
25.0	8.78E-02	4.43E-03
27.5	5.23E-02	2.64E-03
30.0	2.95E-02	1.49E-03
32.5	1.57E-02	7.91E-04
35.0	7.90E-03	3.98E-04
37.5	3.76E-03	1.89E-04
40.0	1.68E-03	8.49E-05
42.5	7.13E-04	3.59E-05
45.0	2.85E-04	1.43E-05
47.5	6.39E-05	3.22E-06
50.0	2.25E-05	1.13E-06

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Arsenic		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	6.40E-02	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	9.90E+100	days	
Calculated decay rate	λ	7.00E-102	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	0.00E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	7.00E-102	d ⁻¹
Rate of contaminant flow due to retardation	u	3.47E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.57E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	4.07E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

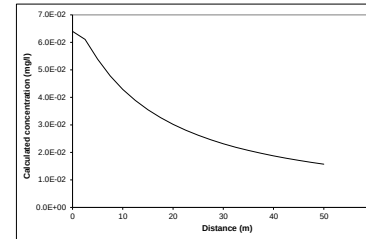
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	0.00E+00 fraction
Organic carbon partition coefficient	Koc	2.51E+03 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	l/kg
Sorption coefficient for ionised species	K _{oc, i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	0.00E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	6.4E-02
2.5	6.11E-02
5.0	5.39E-02
7.5	4.78E-02
10.0	4.29E-02
12.5	3.89E-02
15.0	3.55E-02
17.5	3.26E-02
20.0	3.02E-02
22.5	2.81E-02
25.0	2.62E-02
27.5	2.46E-02
30.0	2.32E-02
32.5	2.19E-02
35.0	2.07E-02
37.5	1.97E-02
40.0	1.87E-02
42.5	1.79E-02
45.0	1.71E-02
47.5	1.64E-02
50.0	1.57E-02

Remedial Targets

Remedial Target	2.04E-01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
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Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.57E-02	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C10-C12 (Naphthalene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C10-C12 (Naphthalene)
0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 2.00E-02 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 2.51E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 2.01E+01 l/kg Calculated value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	1.81E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C10-C12 (Naphthalene)** from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry	Infiltration	Inf	1.77E-04	m/d
	Area of contaminant source	A	5.00E+03	m ²
Entry for groundwater flow below site	Length of contaminant source in direction of groundwater flow	L	1.00E+02	m
	Saturated aquifer thickness	da	7.00E+00	m
	Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d
	Hydraulic gradient of water table	i	4.00E-02	fraction
	Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m
	Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m
	Calculated mixing zone thickness	Mz	7.00E+00	m

Not used in calculation

Not used in calculation

Calculated Parameters

Dilution Factor	DF	4.21E+01	
Level 2 Remedial Target		3.79E+00	mg/l
		or	
		7.62E+01	mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) C_c 0.00E+00 mg/l

Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C10-C12 (Naphtha)		from Level 1
Target Concentration	C _T	0.00	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	109000	mg/kg	
Enter soil concentration	1.29E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.08E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	2.17E+02	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	3.50E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+03 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

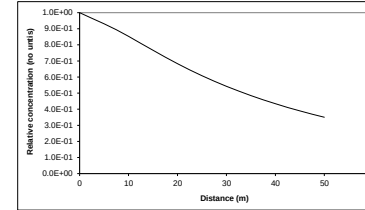
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.29E+02
2.5	9.65E-01	1.24E+02
5.0	9.31E-01	1.20E+02
7.5	8.94E-01	1.15E+02
10.0	8.53E-01	1.10E+02
12.5	8.10E-01	1.04E+02
15.0	7.66E-01	9.87E+01
17.5	7.24E-01	9.32E+01
20.0	6.83E-01	8.80E+01
22.5	6.45E-01	8.30E+01
25.0	6.08E-01	7.84E+01
27.5	5.74E-01	7.40E+01
30.0	5.43E-01	6.99E+01
32.5	5.13E-01	6.60E+01
35.0	4.85E-01	6.24E+01
37.5	4.59E-01	5.91E+01
40.0	4.34E-01	5.59E+01
42.5	4.11E-01	5.29E+01
45.0	3.90E-01	5.02E+01
47.5	3.69E-01	4.76E+01
50.0	3.50E-01	4.51E+01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C10-C12 Naphthalene	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.77E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.29E+02	days	
Calculated decay rate	λ	5.37E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	
Parameters values determined from options				
Partition coefficient	Kd	2.01E+01	l/kg	see options
Longitudinal dispersivity	αx	5.00E+00	m	see options
Transverse dispersivity	αz	5.00E-01	m	see options
Vertical dispersivity	αy	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.44E+02	fraction
Decay rate used	λ	3.73E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	2.40E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	5.69E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	8.39E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

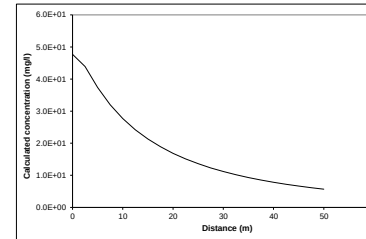
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	2.51E+03	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	2.01E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	4.8E+01
2.5	4.39E+01
5.0	3.74E+01
7.5	3.20E+01
10.0	2.77E+01
12.5	2.42E+01
15.0	2.13E+01
17.5	1.89E+01
20.0	1.69E+01
22.5	1.51E+01
25.0	1.36E+01
27.5	1.23E+01
30.0	1.12E+01
32.5	1.02E+01
35.0	9.31E+00
37.5	8.53E+00
40.0	7.83E+00
42.5	7.21E+00
45.0	6.65E+00
47.5	6.14E+00
50.0	5.69E+00

Remedial Targets

Remedial Target	7.55E-01	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m
Concentration of contaminant at compliance point after	C _{1D} /C ₀	5.69E+00
		1.0E+06
		mg/l
		days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Benzo (a) pyrene		
Target Concentration (C _T)	0.00017	mg/l	Origin of C _T : EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Benzo (a) pyrene
0.00017 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 5.00E-05 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 1.29E+05 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pK_a
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 1.03E+03 l/kg Calculated value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	1.75E-01	mg/kg	(for comparison with soil analyses)
	or		
	0.00017	mg/l	(for comparison with leachate test results)

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T Benzo (a) pyrene 0.00017 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Infiltration	Inf	1.77E-04	m/d	
Area of contaminant source	A	5.00E+03	m ²	Not used in calculation
Entry for groundwater flow below site				
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	
Saturated aquifer thickness	da	7.00E+00	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d	
Hydraulic gradient of water table	i	4.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	7.00E+00	m	

Calculated Parameters

Dilution Factor	DF	4.21E+01		
Level 2 Remedial Target		7.16E-03 or 7.39E+00	mg/l mg/kg	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	Benzo (a) pyrene		from Level 1
Target Concentration	0.00017	mg/l	from Level 1
Dilution Factor	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9710	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.29E+05 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.03E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity ax

Transverse dispersivity az

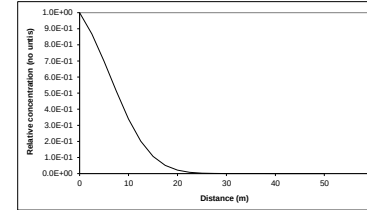
Vertical dispersivity ay

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.23E-01
2.5	8.68E-01	1.94E-01
5.0	6.98E-01	1.56E-01
7.5	5.12E-01	1.14E-01
10.0	3.39E-01	7.58E-02
12.5	2.02E-01	4.51E-02
15.0	1.07E-01	2.40E-02
17.5	5.08E-02	1.14E-02
20.0	2.15E-02	4.80E-03
22.5	8.05E-03	1.80E-03
25.0	2.68E-03	5.98E-04
27.5	7.88E-04	1.76E-04
30.0	2.06E-04	4.59E-05
32.5	4.74E-05	1.06E-05
35.0	5.47E-06	1.22E-06
37.5	9.77E-07	2.18E-07
40.0	1.54E-07	3.44E-08
42.5	2.15E-08	4.79E-09
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Benzo (a) pyrene	from Level 1
Target Concentration	1.70E-04	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.22E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	5.30E+02	days	
Calculated decay rate	λ	1.31E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	
Parameters values determined from options				
Partition coefficient	Kd	1.03E+03	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	7.36E+03	fraction
Decay rate used	λ	1.78E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	4.71E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	4.84E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	8.72E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

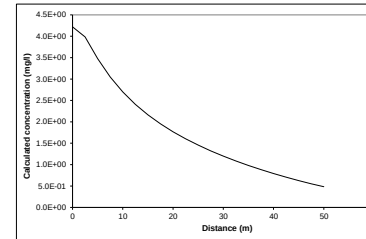
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.29E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc, n}		l/kg
Sorption coefficient for ionised species	K _{oc, i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.03E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.2E+00
2.5	3.99E+00
5.0	3.48E+00
7.5	3.05E+00
10.0	2.70E+00
12.5	2.41E+00
15.0	2.16E+00
17.5	1.95E+00
20.0	1.77E+00
22.5	1.60E+00
25.0	1.46E+00
27.5	1.32E+00
30.0	1.20E+00
32.5	1.09E+00
35.0	9.81E-01
37.5	8.83E-01
40.0	7.91E-01
42.5	7.06E-01
45.0	6.26E-01
47.5	5.52E-01
50.0	4.84E-01

Remedial Targets

Remedial Target	1.48E-03	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	4.84E-01	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C 21-C35 (Fluoranthene)		
Target Concentration (C _T)	0.09	mg/l	Origin of C _T : WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C 21-C35 (Fluoranthene)
0.09 mg/l

Input Parameters

Standard entry

Variable	Value	Unit
Water filled soil porosity θ_w	1.50E-01	fraction
Air filled soil porosity θ_a	1.50E-01	fraction
Bulk density of soil zone material ρ	2.14E+01	g/cm ³
Henry's Law constant H	7.00E-04	dimensionless

Source of parameter value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc}	8.00E-03	fraction
Organic carbon partition coefficient K_{oc}	1.26E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$		l/kg
Sorption coefficient for ionised species $K_{oc,i}$		l/kg
pH value pH		pH units
Acid dissociation constant pK_a		
Fraction of organic carbon (in soil) f_{oc}		fraction

Soil water partition coefficient used in Level Assessment K_d 1.01E+03 l/kg Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	9.07E+01	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C 21-C35 (Fluorant)** from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry	Infiltration	Inf	1.77E-04	m/d
	Area of contaminant source	A	5.00E+03	m ²
Entry for groundwater flow below site	Length of contaminant source in direction of groundwater flow	L	1.00E+02	m
	Saturated aquifer thickness	da	7.00E+00	m
	Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d
	Hydraulic gradient of water table	i	4.00E-02	fraction
	Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m
	Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m
	Calculated mixing zone thickness	Mz	7.00E+00	m

Not used in calculation

Not used in calculation

Calculated Parameters

Dilution Factor	DF	4.21E+01		
Level 2 Remedial Target		3.79E+00	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration
		or		
		3.82E+03	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) C_c 0.00E+00 mg/l

Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C 21-C35 (Fluoranthene)		from Level 1
Target Concentration	C _T	0.00	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	101000	mg/kg	
Enter soil concentration	4.40E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	partitioning equation.
			Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.26E+05 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.01E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

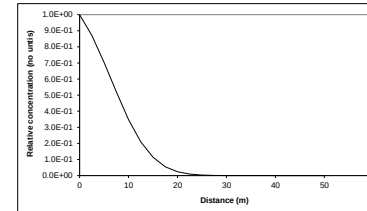
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.38E+00
2.5	8.70E-01	2.07E+00
5.0	7.03E-01	1.67E+00
7.5	5.20E-01	1.24E+00
10.0	3.48E-01	8.28E-01
12.5	2.10E-01	4.99E-01
15.0	1.13E-01	2.70E-01
17.5	5.49E-02	1.31E-01
20.0	2.37E-02	5.63E-02
22.5	9.11E-03	2.17E-02
25.0	3.12E-03	7.41E-03
27.5	9.48E-04	2.25E-03
30.0	2.56E-04	6.09E-04
32.5	6.13E-05	1.46E-04
35.0	7.39E-06	1.76E-05
37.5	1.38E-06	3.28E-06
40.0	2.28E-07	5.42E-07
42.5	3.33E-08	7.92E-08
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C 21-C35 (Fluoranth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	9.89E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	4.40E+02	days	
Calculated decay rate	λ	1.58E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	1.01E+03	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Variable

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	7.19E+03	fraction
Decay rate used	λ	2.19E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	4.82E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.15E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	8.62E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

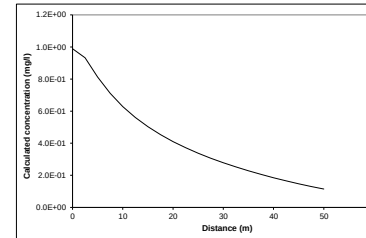
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer	foc		
Organic carbon partition coefficient	Koc	1.26E+05	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,ion}		
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	1.01E+03	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	9.9E-01
2.5	9.33E-01
5.0	8.12E-01
7.5	7.11E-01
10.0	6.29E-01
12.5	5.61E-01
15.0	5.03E-01
17.5	4.53E-01
20.0	4.10E-01
22.5	3.72E-01
25.0	3.38E-01
27.5	3.07E-01
30.0	2.78E-01
32.5	2.52E-01
35.0	2.28E-01
37.5	2.06E-01
40.0	1.85E-01
42.5	1.66E-01
45.0	1.47E-01
47.5	1.30E-01
50.0	1.15E-01

Remedial Targets

Remedial Target	7.76E-01	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{ED} /C ₀	1.15E-01	mg/l
		1.0E+06	days
			Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C12-C16 (Acenaphthylene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C12-C16 (Acenaphth)
0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E-02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+03

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+01

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

3.61E+00

mg/kg

(for comparison with soil analyses)

or

0.09

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C12-C16 (Acenaph)** from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry	Infiltration	Inf	1.77E-04	m/d
	Area of contaminant source	A	5.00E+03	m ²
Entry for groundwater flow below site	Length of contaminant source in direction of groundwater flow	L	1.00E+02	m
	Saturated aquifer thickness	da	7.00E+00	m
	Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d
	Hydraulic gradient of water table	i	4.00E-02	fraction
	Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m
	Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m
	Calculated mixing zone thickness	Mz	7.00E+00	m

Not used in calculation

Not used in calculation

Calculated Parameters

Dilution Factor	DF	4.21E+01		
Level 2 Remedial Target		3.79E+00	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration
		or		
		1.52E+02	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C12-C16 (Acenaph)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	91700	mg/kg	
Enter soil concentration	6.00E+01	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	2.22E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	8.89E+02	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.71E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 0.00E+00 fractionOrganic carbon partition coefficient K_{oc} 0.00E+00 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 0.00E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

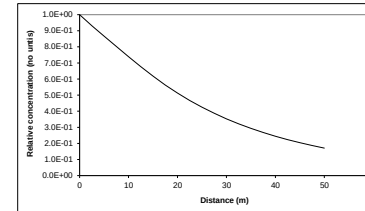
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.43E+01
2.5	9.31E-01	5.06E+01
5.0	8.67E-01	4.71E+01
7.5	8.03E-01	4.36E+01
10.0	7.39E-01	4.01E+01
12.5	6.77E-01	3.67E+01
15.0	6.18E-01	3.35E+01
17.5	5.63E-01	3.06E+01
20.0	5.13E-01	2.78E+01
22.5	4.67E-01	2.54E+01
25.0	4.25E-01	2.31E+01
27.5	3.87E-01	2.10E+01
30.0	3.53E-01	1.92E+01
32.5	3.22E-01	1.75E+01
35.0	2.93E-01	1.59E+01
37.5	2.68E-01	1.45E+01
40.0	2.45E-01	1.33E+01
42.5	2.23E-01	1.21E+01
45.0	2.04E-01	1.11E+01
47.5	1.87E-01	1.01E+01
50.0	1.71E-01	9.28E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C12-C16 (Acenaphth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	6.41E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	6.00E+01	days	
Calculated decay rate	λ	1.16E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	0.00E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	1.16E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	3.47E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	3.67E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.74E+01	

Select Method for deriving Partition Co-efficient (using pull down menu)

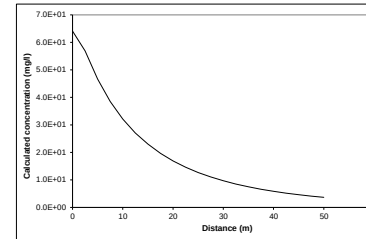
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	K _d	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	f _{oc}	8.00E-03 fraction
Organic carbon partition coefficient	K _{oc}	0.00E+00 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc, n}	l/kg
Sorption coefficient for ionised species	K _{oc, i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	K _d	0.00E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} , α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	6.4E+01
2.5	5.68E+01
5.0	4.67E+01
7.5	3.85E+01
10.0	3.21E+01
12.5	2.71E+01
15.0	2.30E+01
17.5	1.97E+01
20.0	1.69E+01
22.5	1.46E+01
25.0	1.27E+01
27.5	1.11E+01
30.0	9.69E+00
32.5	8.51E+00
35.0	7.49E+00
37.5	6.62E+00
40.0	5.86E+00
42.5	5.20E+00
45.0	4.62E+00
47.5	4.12E+00
50.0	3.67E+00

Remedial Targets

Remedial Target	1.57E+00	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point

50

m

Concentration of contaminant at compliance point after

C_{1D}/C₀

3.67E+00

mg/l

after

1.0E+06

days

Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C16-C21 (Phenanthrene)		
Target Concentration (C_T)	0.09	mg/l	Origin of C_T: WHO

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C16-C21 (Phenanthr
0.09 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 1.30E-02 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 1.58E+04 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pK_a
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 1.26E+02 l/kg Calculated value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	1.14E+01	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C16-C21 (Phenanthrene) from Level 1
0.09 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Standard entry

Input Parameters

Variable

Value

Unit

Source of parameter value

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

3.79E+00
or
4.79E+02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C16-C21 (Phenanthrene)		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	105000	mg/kg	
Enter soil concentration	2.00E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	1.94E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.45E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	1.96E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.58E+04 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.26E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

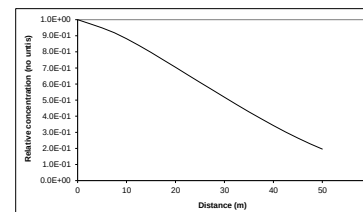
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.97E+01
2.5	9.75E-01	1.92E+01
5.0	9.49E-01	1.87E+01
7.5	9.19E-01	1.81E+01
10.0	8.82E-01	1.74E+01
12.5	8.40E-01	1.66E+01
15.0	7.96E-01	1.57E+01
17.5	7.51E-01	1.48E+01
20.0	7.04E-01	1.39E+01
22.5	6.58E-01	1.30E+01
25.0	6.11E-01	1.20E+01
27.5	5.64E-01	1.11E+01
30.0	5.18E-01	1.02E+01
32.5	4.72E-01	9.32E+00
35.0	4.28E-01	8.43E+00
37.5	3.84E-01	7.58E+00
40.0	3.42E-01	6.75E+00
42.5	3.02E-01	5.96E+00
45.0	2.64E-01	5.21E+00
47.5	2.29E-01	4.51E+00
50.0	1.96E-01	3.86E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C16-C21 (Phenanth)	from Level 1
Target Concentration	C _T	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.90E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	2.00E+02	days	
Calculated decay rate	λ	3.47E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.26E+02	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	9.03E+02	fraction
Decay rate used	λ	3.84E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	3.84E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	7.47E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	6.56E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

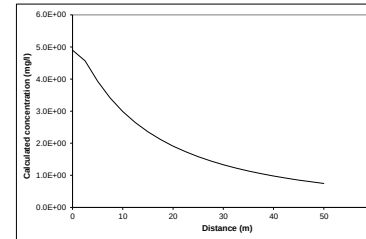
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.58E+04	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	1.26E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	4.9E+00
2.5	4.57E+00
5.0	3.93E+00
7.5	3.41E+00
10.0	2.99E+00
12.5	2.64E+00
15.0	2.36E+00
17.5	2.12E+00
20.0	1.91E+00
22.5	1.73E+00
25.0	1.58E+00
27.5	1.45E+00
30.0	1.33E+00
32.5	1.23E+00
35.0	1.14E+00
37.5	1.05E+00
40.0	9.79E-01
42.5	9.12E-01
45.0	8.52E-01
47.5	7.97E-01
50.0	7.47E-01

Remedial Targets

Remedial Target	5.91E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	7.47E-01	mg/l
		1.0E+06	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C8-C10 (Xylene)		
Target Concentration (C_T)	0.5	Origin of C_T:	DWS
	mg/l		

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C8-C10 (Xylene)
0.5 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 2.90E-01 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 8.00E-03 fraction
Organic carbon partition coefficient K_{oc} 1.59E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) f_{oc} fraction

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment K_d 1.27E+01 l/kg Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	6.36E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.5	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C8-C10 (Xylene)
0.5

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

2.11E+01
or
2.68E+02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C8-C10 (Xylene)		from Level 1
Target Concentration	C _T	0.5	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	7170	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	3.55E-01	m/d
Retardation factor	Rf	9.08E+02	fraction
Decay rate used	λ	4.24E-06	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.10E-02	fraction
Rate of contaminant flow due to retardation	u	3.91E-04	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	4.24E-01	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	2.36E+00	fraction
Calculated soil leachate concentration	Co	5.63E+02	mg/l

Remedial Targets

Level 3 Remedial Target	4.97E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	6.33E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	4.24E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.59E+03 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 1.27E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

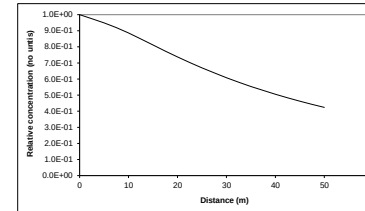
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.34E+01
2.5	9.75E-01	1.30E+01
5.0	9.49E-01	1.27E+01
7.5	9.20E-01	1.23E+01
10.0	8.86E-01	1.18E+01
12.5	8.49E-01	1.14E+01
15.0	8.11E-01	1.08E+01
17.5	7.74E-01	1.03E+01
20.0	7.38E-01	9.86E+00
22.5	7.03E-01	9.39E+00
25.0	6.69E-01	8.95E+00
27.5	6.38E-01	8.53E+00
30.0	6.08E-01	8.13E+00
32.5	5.80E-01	7.76E+00
35.0	5.54E-01	7.41E+00
37.5	5.29E-01	7.08E+00
40.0	5.06E-01	6.76E+00
42.5	4.84E-01	6.47E+00
45.0	4.63E-01	6.18E+00
47.5	4.43E-01	5.92E+00
50.0	4.24E-01	5.67E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C8-C10 (Xylene)	from Level 1
Target Concentration	C _T 5.00E-01	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	7.10E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.27E+01	l/kg	see options
Longitudinal dispersivity	αx	5.00E+00	m	see options
Transverse dispersivity	αz	5.00E-01	m	see options
Vertical dispersivity	αy	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	9.17E+01	fraction
Decay rate used	λ	4.20E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	3.78E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.03E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	6.90E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

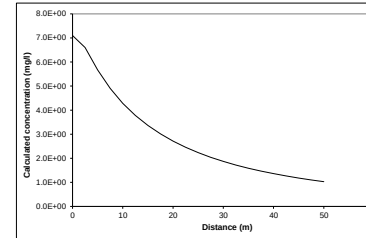
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.59E+03	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	1.27E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	αx	5.00E+00	5.00E+00	5.00E+00
Transverse dispersivity	αz	5.00E-01	5.00E-01	5.00E-01
Vertical dispersivity	αy	5.00E-02	5.00E-02	5.00E-02
Note values of dispersivity must be > 0				
For calculated value, assumes αx = 0.1 * x, αz = 0.01 * x, αy = 0.001 * x				
Xu & Eckstein (1995) report αx = 0.83(log ₁₀ x) ^{-0.414} ; αz = αx/10, αy = αx/100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	7.1E+00
2.5	6.60E+00
5.0	5.67E+00
7.5	4.90E+00
10.0	4.28E+00
12.5	3.78E+00
15.0	3.36E+00
17.5	3.01E+00
20.0	2.71E+00
22.5	2.46E+00
25.0	2.23E+00
27.5	2.04E+00
30.0	1.87E+00
32.5	1.72E+00
35.0	1.59E+00
37.5	1.47E+00
40.0	1.36E+00
42.5	1.27E+00
45.0	1.18E+00
47.5	1.10E+00
50.0	1.03E+00

Remedial Targets

Remedial Target	3.45E+00	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
Concentration of contaminant at compliance point after	C _{1D} /C ₀	1.03E+00
		1.0E+06
		days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C7-C8 (Toluene)		
Target Concentration (C_T)	0.074	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C7-C8 (Toluene)

0.074 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

2.72E-01

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

2.51E+02

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.01E+00

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

1.49E-01

mg/kg

(for comparison with soil analyses)

or

0.074

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C7-C8 (Toluene)
0.074

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

3.12E+00
or
6.29E+00

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C7-C8 (Toluene)		from Level 1
Target Concentration	C _T	0.074	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
--------------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	185	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	3.55E-01 m/d
Retardation factor	Rf	1.44E+02 fraction
Decay rate used	λ	3.43E-04 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.10E-02 fraction
Rate of contaminant flow due to retardation	u	2.46E-03 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	6.25E-03 fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	1.60E+02 fraction
Calculated soil leachate concentration	Co	9.17E+01 mg/l

Remedial Targets

Level 3 Remedial Target	4.99E+02	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.01E+03	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C₁₀₀/C₀	6.25E-03	fraction Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+02 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

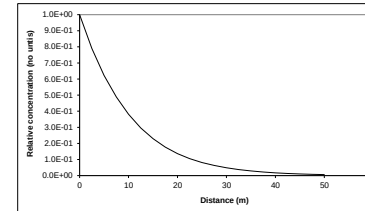
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	2.18E+00
2.5	7.89E-01	1.72E+00
5.0	6.23E-01	1.36E+00
7.5	4.89E-01	1.06E+00
10.0	3.81E-01	8.30E-01
12.5	2.96E-01	6.44E-01
15.0	2.29E-01	4.99E-01
17.5	1.77E-01	3.85E-01
20.0	1.37E-01	2.97E-01
22.5	1.05E-01	2.29E-01
25.0	8.13E-02	1.77E-01
27.5	6.28E-02	1.37E-01
30.0	4.85E-02	1.06E-01
32.5	3.75E-02	8.15E-02
35.0	2.90E-02	6.30E-02
37.5	2.24E-02	4.88E-02
40.0	1.73E-02	3.77E-02
42.5	1.34E-02	2.92E-02
45.0	1.04E-02	2.26E-02
47.5	8.06E-03	1.76E-02
50.0	6.25E-03	1.36E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant		Aromatic C7-C8 (Toluene)	from Level 1
Target Concentration	C _T	7.40E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.80E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.40E+01	days	
Calculated decay rate	λ	4.95E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	2.01E+00	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Variable

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.53E+01	fraction
Decay rate used	λ	3.23E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	2.26E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	3.57E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	5.04E+02	

Select Method for deriving Partition Co-efficient (using pull down menu)

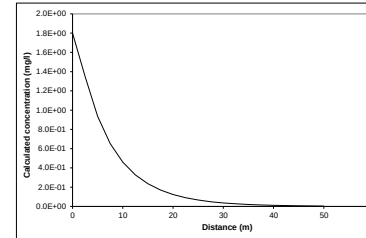
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	2.51E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.01E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	5.00E+00
Transverse dispersivity	α _z	5.00E-01	5.00E-01	5.00E-01
Vertical dispersivity	α _y	5.00E-02	5.00E-02	5.00E-02
Note values of dispersivity must be > 0				
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed				



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.8E+00
2.5	1.35E+00
5.0	9.36E-01
7.5	6.53E-01
10.0	4.60E-01
12.5	3.28E-01
15.0	2.35E-01
17.5	1.70E-01
20.0	1.24E-01
22.5	9.03E-02
25.0	6.63E-02
27.5	4.88E-02
30.0	3.61E-02
32.5	2.68E-02
35.0	2.00E-02
37.5	1.49E-02
40.0	1.12E-02
42.5	8.36E-03
45.0	6.29E-03
47.5	4.73E-03
50.0	3.57E-03

Remedial Targets

Remedial Target	3.73E+01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	3.57E-03	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aromatic C5-C7 (Benzene)		
Target Concentration (C_T)	0.01	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C5-C7 (Benzene)

0.01 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E+02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+06

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+04

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

4.01E+02

mg/kg

(for comparison with soil analyses)

or

0.01

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C5-C7 (Benzene)
0.01

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

4.21E-01
or
1.69E+04

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C5-C7 (Benzene)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	950	mg/kg	
Enter soil concentration	1.80E+02	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	ay	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	partitioning equation.
			Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 5.01E+06 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 4.01E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 5.00E+00 2.00E+00 m

Transverse dispersivity az 0.00E+00 5.00E-01 2.00E-01 m

Vertical dispersivity ay 0.00E+00 5.00E-02 2.00E-02 m

Note values of dispersivity must be > 0

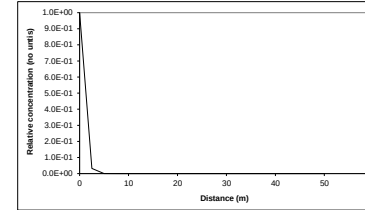
Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	5.63E-04
2.5	3.18E-02	1.79E-05
5.0	1.18E-05	6.66E-09
7.5	0.00E+00	0.00E+00
10.0	0.00E+00	0.00E+00
12.5	0.00E+00	0.00E+00
15.0	0.00E+00	0.00E+00
17.5	0.00E+00	0.00E+00
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C5-C7 (Benzene)	from Level 1
Target Concentration	C _T 1.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	8.65E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	4.01E+04	l/kg	see options
Longitudinal dispersivity	α _x	5.00E+00	m	see options
Transverse dispersivity	α _z	5.00E-01	m	see options
Vertical dispersivity	α _y	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	2.86E+05	fraction
Decay rate used	λ	1.35E-08	d ⁻¹
Rate of contaminant flow due to retardation	u	1.21E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	0.00E+00	mg/l
Attenuation factor (one way vertical dispersion, COICED)	AF	breakthrough at compliance point	

Select Method for deriving Partition Co-efficient (using pull down menu)

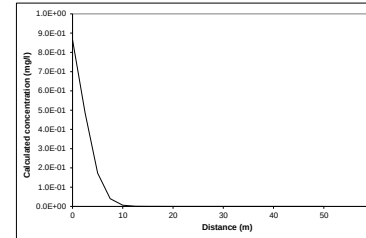
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	8.00E-03 fraction
Organic carbon partition coefficient	Koc	5.01E+06 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	4.01E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	α _z	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	α _y	5.00E-02	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x					
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{-0.414} ; α _z = α _x /10, α _y = α _x /100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action. Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.7E-01
2.5	4.86E-01
5.0	1.73E-01
7.5	4.04E-02
10.0	6.05E-03
12.5	5.69E-04
15.0	3.32E-05
17.5	1.19E-06
20.0	1.39E-08
22.5	0.00E+00
25.0	0.00E+00
27.5	0.00E+00
30.0	0.00E+00
32.5	0.00E+00
35.0	0.00E+00
37.5	0.00E+00
40.0	0.00E+00
42.5	0.00E+00
45.0	0.00E+00
47.5	0.00E+00
50.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{1D} /C ₀	0.00E+00 1.0E+06	mg/l days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aliphatic C12-C16		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aliphatic C12-C16

0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01

fraction

Air filled soil porosity

θ_a

1.50E-01

fraction

Bulk density of soil zone material

ρ

2.14E+01

g/cm³

Henry's Law constant

H

5.40E+02

dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

8.00E-03

fraction

Organic carbon partition coefficient

K_{oc}

5.01E+06

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

4.01E+04

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

2.00E+03

mg/kg

(for comparison with soil analyses)

or

0.05

mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Aliphatic C12-C16** from Level 1
0.05 mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Infiltration	Inf	1.77E-04	m/d	
Area of contaminant source	A	5.00E+03	m ²	Not used in calculation
Entry for groundwater flow below site				
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	
Saturated aquifer thickness	da	7.00E+00	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.60E+00	m/d	
Hydraulic gradient of water table	i	4.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.50E+01	m	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	1.00E-07	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	7.00E+00	m	

Calculated Parameters

Dilution Factor	DF	4.21E+01		
Level 2 Remedial Target		2.11E+00 or 8.44E+04	mg/l mg/kg	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic C12-C16		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	950	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	partitioning equation.
			Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,rel} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 4.01E+04 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

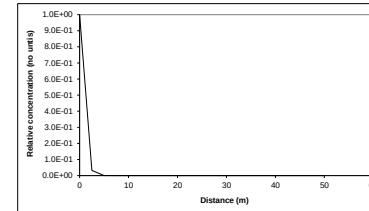
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	5.63E-04
2.5	3.18E-02	1.79E-05
5.0	1.18E-05	6.66E-09
7.5	0.00E+00	0.00E+00
10.0	0.00E+00	0.00E+00
12.5	0.00E+00	0.00E+00
15.0	0.00E+00	0.00E+00
17.5	0.00E+00	0.00E+00
20.0	0.00E+00	0.00E+00
22.5	0.00E+00	0.00E+00
25.0	0.00E+00	0.00E+00
27.5	0.00E+00	0.00E+00
30.0	0.00E+00	0.00E+00
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aliphatic C12-C16		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	8.65E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	4.01E+04	l/kg	see options
Longitudinal dispersivity	ax	5.00E+00	m	see options
Transverse dispersivity	az	5.00E-01	m	see options
Vertical dispersivity	ay	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	2.86E+05	fraction
Decay rate used	λ	1.35E-08	d ⁻¹
Rate of contaminant flow due to retardation	u	1.21E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	0.00E+00	mg/l

Attenuation factor (one way vertical dispersion, COICED) AF breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

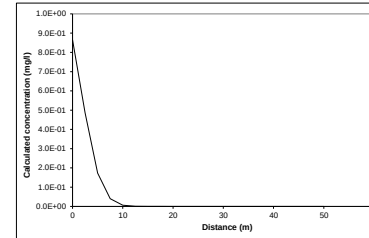
Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	5.01E+06	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.01E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.414}; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.7E-01
2.5	4.86E-01
5.0	1.73E-01
7.5	4.04E-02
10.0	6.05E-03
12.5	5.69E-04
15.0	3.32E-05
17.5	1.19E-06
20.0	1.39E-08
22.5	0.00E+00
25.0	0.00E+00
27.5	0.00E+00
30.0	0.00E+00
32.5	0.00E+00
35.0	0.00E+00
37.5	0.00E+00
40.0	0.00E+00
42.5	0.00E+00
45.0	0.00E+00
47.5	0.00E+00
50.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
-----------------	-----------	------	---

Ogata Banks

Distance to compliance point 50 m

Concentration of contaminant at compliance point after	C _{1D} /C ₀	0.00E+00	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Aliphatic C10-C12		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T 0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 1.30E+02 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) foc 8.00E-03 fraction

Organic carbon partition coefficient K_{oc} 2.51E+05 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species K_{oc,n} l/kg

Sorption coefficient for ionised species K_{oc,i} l/kg

pH value pH pH units

Acid dissociation constant pK_a

Fraction of organic carbon (in soil) foc fraction

Soil water partition coefficient used in Level Assessment K_d 2.01E+03 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target 1.00E+02 mg/kg (for comparison with soil analyses)

or
0.05 mg/l (for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aliphatic C10-C12
0.05

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

2.11E+00

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

4.23E+03

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic C10-C12		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	711	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	No impact	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	No impact	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	0.00E+00	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 8.00E-03 fractionOrganic carbon partition coefficient K_{oc} 2.51E+05 l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 2.01E+03 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity

Transverse dispersivity

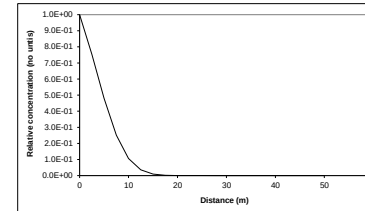
Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	8.40E-03
2.5	7.54E-01	6.33E-03
5.0	4.80E-01	4.03E-03
7.5	2.52E-01	2.11E-03
10.0	1.06E-01	8.94E-04
12.5	3.60E-02	3.02E-04
15.0	9.67E-03	8.13E-05
17.5	2.06E-03	1.73E-05
20.0	3.45E-04	2.90E-06
22.5	4.55E-05	3.82E-07
25.0	4.71E-06	3.96E-08
27.5	2.09E-07	1.76E-09
30.0	1.32E-08	1.11E-10
32.5	0.00E+00	0.00E+00
35.0	0.00E+00	0.00E+00
37.5	0.00E+00	0.00E+00
40.0	0.00E+00	0.00E+00
42.5	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00
47.5	0.00E+00	0.00E+00
50.0	0.00E+00	0.00E+00

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aliphatic C10-C12		from Level 1
Target Concentration	C _T	5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	3.52E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.80E+02	days	
Calculated decay rate	λ	3.85E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.01E+03	l/kg	see options
Longitudinal dispersivity	αx	5.00E+00	m	see options
Transverse dispersivity	αz	5.00E-01	m	see options
Vertical dispersivity	αy	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	1.43E+04	fraction
Decay rate used	λ	2.69E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	2.42E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	4.75E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	7.42E+01	

Select Method for deriving Partition Co-efficient (using pull down menu)

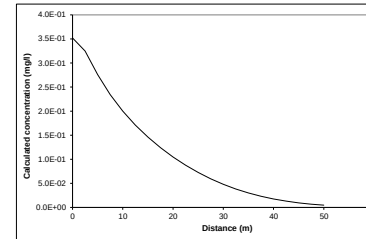
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	8.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	2.51E+05	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,rel}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	2.01E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	αx	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	αz	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	αy	0.00E+00	5.00E-02	2.98E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes αx = 0.1 * x, αz = 0.01 * x, αy = 0.001 * x					
Xu & Eckstein (1995) report αx = 0.83(log ₁₀ x) ^{-0.414} ; αz = αx/10, αy = αx/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration

	mg/l
0	3.5E-01
2.5	3.25E-01
5.0	2.76E-01
7.5	2.34E-01
10.0	2.00E-01
12.5	1.71E-01
15.0	1.46E-01
17.5	1.24E-01
20.0	1.05E-01
22.5	8.76E-02
25.0	7.26E-02
27.5	5.94E-02
30.0	4.80E-02
32.5	3.82E-02
35.0	3.00E-02
37.5	2.31E-02
40.0	1.75E-02
42.5	1.30E-02
45.0	9.48E-03
47.5	6.78E-03
50.0	4.75E-03

Remedial Targets

Remedial Target	3.71E+00	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point	50	m
------------------------------	----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	4.75E-03	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Moncton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Thiocyanate		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : Surf Water

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant
Target concentration

C_T

Thiocyanate
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity

θ_w

1.50E-01 fraction

Air filled soil porosity

θ_a

1.50E-01 fraction

Bulk density of soil zone material

ρ

2.14E+01 g/cm³

Henry's Law constant

H

0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

fraction

Organic carbon partition coefficient

K_{oc}

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

9.90E+00 l/kg

Specified value

Level 1 Remedial Target

Level 1 Remedial Target

4.95E-01 mg/kg

(for comparison with soil analyses)

or

0.05 mg/l

(for comparison with leachate test results)

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15-Jul-20

Version: Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Thiocyanate
0.05

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

2.11E+00
or
2.09E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Thiocyanate		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	9	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	m/d
Retardation factor	Rf	fraction
Decay rate used	λ	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	fraction
Rate of contaminant flow due to retardation	u	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	fraction
Calculated soil leachate concentration	Co	mg/l

Remedial Targets

Level 3 Remedial Target	6.86E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	6.80E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	300	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	3.07E-02	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,li} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 9.90E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity ax 0.00E+00 3.00E+01 7.41E+00 m

Transverse dispersivity az 0.00E+00 3.00E+00 7.41E+01 m

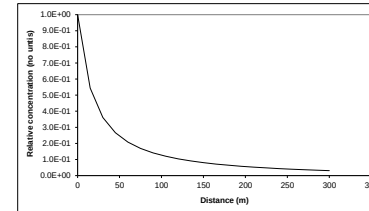
Vertical dispersivity ay 0.00E+00 3.00E+01 7.41E+02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{2.414}, az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.16E-02
15.0	5.44E-01	1.17E-02
30.0	3.61E-01	7.79E-03
45.0	2.66E-01	5.74E-03
60.0	2.08E-01	4.48E-03
75.0	1.69E-01	3.65E-03
90.0	1.41E-01	3.04E-03
105.0	1.20E-01	2.59E-03
120.0	1.04E-01	2.24E-03
135.0	9.10E-02	1.96E-03
150.0	8.04E-02	1.73E-03
165.0	7.16E-02	1.54E-03
180.0	6.42E-02	1.38E-03
195.0	5.79E-02	1.25E-03
210.0	5.24E-02	1.13E-03
225.0	4.77E-02	1.03E-03
240.0	4.35E-02	9.37E-04
255.0	3.97E-02	8.57E-04
270.0	3.64E-02	7.85E-04
285.0	3.34E-02	7.21E-04
300.0	3.07E-02	6.62E-04

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Thiocyanate	from Level 1
Target Concentration	C _T 5.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.50E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days	
Calculated decay rate	λ	6.93E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	3.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	ax	3.00E+01	m	see options
Transverse dispersivity	az	3.00E+00	m	see options
Vertical dispersivity	ay	3.00E-01	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	7.16E+01	fraction
Decay rate used	λ	9.68E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	4.84E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	1.18E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.12E+02	

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

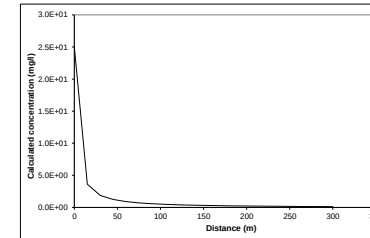
Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	foc		
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc, n}		l/kg
Sorption coefficient for related species	K _{oc, n}		
Sorption coefficient for ionised species	pH		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.90E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	3.00E+01	7.41E+00	m
Vertical dispersivity	ay	0.00E+00	3.00E+00	7.41E-01	m
Note values of dispersivity must be > 0					

For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.414}; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	2.5E+01
15.0	3.62E+00
30.0	1.87E+00
45.0	1.23E+00
60.0	9.08E-01
75.0	7.10E-01
90.0	5.78E-01
105.0	4.83E-01
120.0	4.11E-01
135.0	3.56E-01
150.0	3.12E-01
165.0	2.76E-01
180.0	2.46E-01
195.0	2.21E-01
210.0	2.00E-01
225.0	1.81E-01
240.0	1.65E-01
255.0	1.51E-01
270.0	1.39E-01
285.0	1.28E-01
300.0	1.18E-01

Remedial Targets

Remedial Target	1.06E+01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point 300 m

Concentration of contaminant at compliance point after C_{1D}/C₀ 1.18E-01 mg/l
1.0E+06 days Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed: Moncton Coking Works
Completed by: A Wilson
Date: 15/7/2020
Version: Northern Plume



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Monckton Coking Works		
Site Address:	Lund Hill Lane, Royston		
Completed by:	A Wilson		
Date:	15-Jul-20	Version:	Northern Plume
Contaminant	Cyanide (total)		
Target Concentration (C_T)	0.05	mg/l	Origin of C_T: Surf Water

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant
Target concentration
 C_T

Cyanide (total)
0.05 mg/l

Input Parameters

Standard entry

Water filled soil porosity θ_w 1.50E-01 fraction
Air filled soil porosity θ_a 1.50E-01 fraction
Bulk density of soil zone material ρ 2.14E+01 g/cm³
Henry's Law constant H 0.00E+00 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) foc
Organic carbon partition coefficient Koc

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) foc fraction

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment Kd 9.90E+00 l/kg Specified value

Level 1 Remedial Target

Level 1 Remedial Target	4.95E-01	mg/kg	(for comparison with soil analyses)
	or		
	0.05	mg/l	(for comparison with leachate test results)

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15-Jul-20
Version:	Northern Plume

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Cyanide (total)
0.05

mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

1.77E-04
5.00E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.00E+02
7.00E+00
2.60E+00
4.00E-02
1.50E+01
1.00E-07

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
7.00E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.21E+01

Level 2 Remedial Target

2.11E+00
or
2.09E+01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Monckton Coking Works
Completed by: A Wilson
Date: 15-Jul-20
Version: Northern Plume

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Cyanide (total)		from Level 1
Target Concentration	C _T	0.05	mg/l	from Level 1
Dilution Factor	DF	4.21E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	7800	mg/kg	
Enter soil concentration	1.00E+03	days	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	3.55E-01 m/d
Retardation factor	Rf	7.07E-02 fraction
Decay rate used	λ	9.80E-07 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.10E-02 fraction
Rate of contaminant flow due to retardation	u	5.02E-04 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	3.07E-02 fraction
Attenuation factor (C ₀ /C ₁₀₀)	AF	3.26E+01
Calculated soil leachate concentration	Co	7.87E+02 mg/l

Remedial Targets

Level 3 Remedial Target	6.86E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	6.80E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	300	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀₀ /C ₀	3.07E-02	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 9.90E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kgSorption coefficient for related species K_{oc,rel} l/kgSorption coefficient for ionised species K_{oc,li} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient Kd 9.90E+00 l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Enter value Calc value Xu & Eckstein

Longitudinal dispersivity ax 0.00E+00 3.00E+01 7.41E+00 m

Transverse dispersivity az 0.00E+00 3.00E+00 7.41E+01 m

Vertical dispersivity ay 0.00E+00 3.00E-01 7.41E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}, az = ax/10, ay = ax/100 are assumed

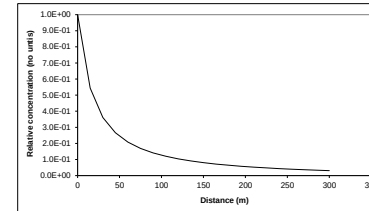
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.87E+01
15.0	5.44E-01	1.02E+01
30.0	3.61E-01	6.75E+00
45.0	2.66E-01	4.97E+00
60.0	2.08E-01	3.89E+00
75.0	1.69E-01	3.16E+00
90.0	1.41E-01	2.64E+00
105.0	1.20E-01	2.25E+00
120.0	1.04E-01	1.94E+00
135.0	9.10E-02	1.70E+00
150.0	8.04E-02	1.50E+00
165.0	7.16E-02	1.34E+00
180.0	6.42E-02	1.20E+00
195.0	5.79E-02	1.08E+00
210.0	5.24E-02	9.80E-01
225.0	4.77E-02	8.91E-01
240.0	4.35E-02	8.12E-01
255.0	3.97E-02	7.43E-01
270.0	3.64E-02	6.80E-01
285.0	3.34E-02	6.24E-01
300.0	3.07E-02	5.74E-01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Monckton Coking Works

Completed by: A Wilson

Date: 15/7/2020

Version: Northern Plume

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	C _T	Cyanide (total)	mg/l	from Level 1
Target Concentration	C _T	5.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.34E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days	
Calculated decay rate	λ	6.93E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	
Plume thickness at source	Sy	1.00E+00	m	
Saturated aquifer thickness	da	7.00E+00	m	
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.00E-02	fraction	
Hydraulic conductivity of aquifer	K	2.60E+00	m/d	
Distance to compliance point	x	3.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+06	days	

Parameters values determined from options

Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	α _x	3.00E+01	m	see options
Transverse dispersivity	α _z	3.00E+00	m	see options
Vertical dispersivity	α _y	3.00E-01	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.47E-01	m/d
Retardation factor	Rf	7.16E+01	fraction
Decay rate used	λ	9.68E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	4.84E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{1D}	2.05E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.12E+02	

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

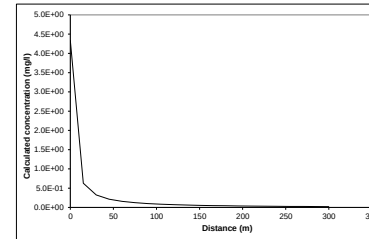
Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Soil water partition coefficient	K _d		
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	foc		
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,ion}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	9.90E+00	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity	α _x	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	α _z	0.00E+00	3.00E+01	7.41E+00	m
Vertical dispersivity	α _y	0.00E+00	3.00E+00	7.41E-01	m
Note values of dispersivity must be > 0					

For calculated value, assumes α_x = 0.1 * x, α_z = 0.01 * x, α_y = 0.001 * x
Xu & Eckstein (1995) report α_x = 0.83(log₁₀x)^{-0.414}; α_z = α_x/10, α_y = α_x/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks	From calculation sheet
Distance	Concentration

	mg/l
0	4.3E+00
15.0	6.29E-01
30.0	3.23E-01
45.0	2.14E-01
60.0	1.57E-01
75.0	1.23E-01
90.0	1.00E-01
105.0	8.37E-02
120.0	7.13E-02
135.0	6.17E-02
150.0	5.41E-02
165.0	4.78E-02
180.0	4.27E-02
195.0	3.83E-02
210.0	3.46E-02
225.0	3.14E-02
240.0	2.86E-02
255.0	2.62E-02
270.0	2.41E-02
285.0	2.22E-02
300.0	2.05E-02

Remedial Targets

Remedial Target	1.06E+01	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Ogata Banks

Distance to compliance point	300	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	C _{1D} /C ₀	2.05E-02	mg/l	Ogata Banks
		1.0E+06	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Monckton Coking Works
Completed by:	A Wilson
Date:	15/7/2020
Version:	Northern Plume

Appendix E

JIWG Asbestos Screening

Decision Support Tool for Receptor Risk Ranking

Stage 1 Hazard Identification		Score
Select ACM type (run model for each type to generate 'Worst Case' output)	Free dispersed fibres/fibre bundles	2
Extent of degradation of ACMs	Disaggregated (dominated by loose fibrous material; extreme degradation in ACM and/or free asbestos fibres/fibre bundles)	4
Friability and degree of bonding by matrix (ACM matrix, not ground materials)	Friable ACM or ACM with fibres not linked in any matrix (free dispersed fibres/fibre bundles)	4
Distribution of Visible Asbestos Across Affected Area	No visible ACMs/fibre bundles	0
Asbestos fibre type	Chrysotile alone	0
Sub-total		10
Hazard ranking		Low

No warranty, expressed or implied, or reliance, is provided in relation to the use of this tool.
 It is contingent on users to satisfy themselves that the output from the tool is relevant and appropriate to the assessment being made.

Stage 2		Score
Emission Factors		
Amount of asbestos fibre in selected ACM/fibre type as % of host material	Very Low quantities - 0.001 to 0.01 %wt/wt	1
Respirable fibre index for ACM - RIVM report 711701034 (2003)	Very low	1
Activity type and effect on deterioration of ACMs	Moderate disturbance, slight deterioration expected	3
Best description of primary host material matrix	Made Ground - Recycled Aggregate, Track Ballast	4
Sub-total		9
Exposure ranking		Low

Stage 3		Score	
Pathway and Receptor Sensitivity			
Receptor category	Residential	No score required	
Age of Receptor	Infant (under 5)	4	
Duration of exposure/site occupancy	>> 10 hours per day (e.g. 24 hour residential exposure)	4	
Receptor ranking		8	High
Combined hazard, exposure and receptor ranking			Medium
Pathway: Distance of Receptor from Source	In or within 10m of area of disturbance	4	
Pathway: Depth to impacted material	Material buried at depth, unlikely to be disturbed except for deeper construction related excavation	B	
Pathway ranking		4B	Very Low
Overall ranking			Very Low



Joint Industry Working Group
Asbestos in Soil and Construction & Demolition Materials

Project Reference	Stockyard
Site Name	Monckton Coking Works
Client	Monckton Developments Limited
Run by	AW
Date	23.7.20
Reviewed by	AW
Characterisation of scenario being evaluated	Residential development with land level raise.
Interpretation of scenario ranking by DST	Interpreted as very low hazard.

Decision Support Tool for Receptor Risk Ranking

Stage 1 Hazard Identification		Score
Select ACM type (run model for each type to generate 'Worst Case' output)	Free dispersed fibres/fibre bundles	2
Extent of degradation of ACMs	Disaggregated (dominated by loose fibrous material; extreme degradation in ACM and/or free asbestos fibres/fibre bundles)	4
Friability and degree of bonding by matrix (ACM matrix, not ground materials)	Friable ACM or ACM with fibres not linked in any matrix (free dispersed fibres/fibre bundles)	4
Distribution of Visible Asbestos Across Affected Area	No visible ACMs/fibre bundles	0
Asbestos fibre type	Mainly amosite (and possible trace tremolite/anthophyllite) with/without chrysotile (no crocidolite)	3
Sub-total		13
Hazard ranking		Medium

No warranty, expressed or implied, or reliance, is provided in relation to the use of this tool.
 It is contingent on users to satisfy themselves that the output from the tool is relevant and appropriate to the assessment being made.

Stage 2		Score
Emission Factors		
Amount of asbestos fibre in selected ACM/fibre type as % of host material	Low quantities - >0.01 to <0.05 %wt/wt	2
Respirable fibre index for ACM - RIVM report 711701034 (2003)	Very low	1
Activity type and effect on deterioration of ACMs	Moderate disturbance, slight deterioration expected	3
Best description of primary host material matrix	Made Ground - Recycled Aggregate, Track Ballast	4
Sub-total		10
Exposure ranking		Medium

Stage 3 Pathway and Receptor Sensitivity		Score	
Receptor category	Residential	No score required	
Age of Receptor	Infant (under 5)	4	
Duration of exposure/site occupancy	>> 10 hours per day (e.g. 24 hour residential exposure)	4	
Receptor ranking		8	High
Combined hazard, exposure and receptor ranking			Medium
Pathway: Distance of Receptor from Source	In or within 10m of area of disturbance	4	
Pathway: Depth to impacted material	Material buried at shallow depth, potential to be disturbed by excavation	C	
Pathway ranking		4C	Low
Overall ranking			Low



Joint Industry Working Group

Asbestos in Soil and Construction & Demolition Materials

Project Reference	Production Area
Site Name	Monckton Coking Works
Client	Monckton Developments Limited
Run by	AW
Date	23.7.20
Reviewed by	AW
Characterisation of scenario being evaluated	Residential development with land level raise.
Interpretation of scenario ranking by DST	Interpreted as low hazard